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INTRODUCING THE CONTRIBUTORS

In the symposium, "Science Education in the Post-War World," recently carried in SCIENCE EDUCATION, many suggestions were made which dealt with the responsibility of science teachers for the education of young people in the area of health. In the present issue of the Journal, the importance and scope of health education are discussed by BERNHARD J. STERN. Dr. Stern is a sociologist whose books include *The Family, Past and Present* and *Society and Medical Progress*. He is also known as the editor of *When Peoples Meet*.

Many science teachers have expressed concern about the way in which their students read. In an article by RUTH STRANG appear some very practical suggestions for those who believe it their obligation to foster the application of scientific method to the reading of scientific materials. Dr. Strang, Professor of Education at Teachers College, Columbia University, is widely known as the author of books in the fields of reading, child study, health, student personnel work, and guidance.

The responsibility of science teachers for recruitment to their profession is one not often presented. LEE R. YOTHERS discussed this subject before the November meeting of the New Jersey Science Teachers Association, of which he is a section chairman. Mr. Yothers is head of the science department of the Rahway, New Jersey, High School. He has contributed articles to SCIENCE EDUCATION in the past, and has served as associate editor of *The American Biology Teacher*.

TUNIS BAKER reports an activity in which the members of a class of prospective elementary school teachers were able to practice and improve their understanding of scientific method. Dr. Baker is head of the science and mathematics department of the New Jersey State Teachers College in Paterson. He is the author of *Science Units for Elementary Schools* and co-author of *In the World of Science*, a series of textbooks for grades 4, 5, and 6.

As an aspect of the general problem of the development of concepts in relation to scientific thinking, CONWELL D. HIGGINS studied changes in the inductive ability of high school students. Dr. Higgins summarizes his study briefly in this issue. *The Journal of Experimental Education* for September, 1944, included a report on one aspect of it: pupil inference.

A summary of the aims and plans of science educators in Cleveland, Ohio, is presented by ARTHUR O. BAKER, directing supervisor of science in the Cleveland schools. Mr. Baker is known far beyond Cleveland, especially for the widely used biology textbook of which he is co-author.

The paper by RALPH W. DEXTER suggests the author's interest in bird study and in the teaching of biology; he reports a special interest in marine ecology and the ecology of mollusks and crustacea. Dr. Dexter is a contributor to journals of natural history and science, and is active in scientific societies.

The Department of Educational Trends is given over for the second time to a discussion of *Education for All American Youth*, this time presenting the expressed viewpoints of a biologist, DR. OSCAR RIDDLE, and of an engineer, DR. HARRY P. HAMMOND.

The Research Department carries a somewhat detailed summary of a part of a doctoral dissertation by W. EDGAR MARTIN, which was done at the University of Michigan under the sponsorship of the editor of this Department, FRANCIS D. CURTIS. There is also a proposal by SHAILER PETERSON of the University of Chicago. Dr. Peterson suggests an attempt directed toward meeting a very real need on the part of research workers in science teaching.

SCIENCE EDUCATION

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HEALTH EDUCATION: ITS IMPORTANCE AND SUBJECT MATTER*

BERNHARD J. STERN
Columbia University

HEALTH education in the secondary schools has come to be conceived of as an integral part of the war program. The demands of a war economy have made more imperative than ever the education of the nation's people in methods of maintaining health and avoiding disease. The results of the selective service, which found very many of the youth of the United States unfit for army service because of physical disabilities, have made the country aware that previous measures in the field of health, including education, have been woefully inadequate.

There are other factors also which stress the urgency of health education at this time. In fulfilling the war production program the civilian population is obliged to work longer hours and at greater tempo than in the prewar period. The illnesses which have kept men from work at considerable economic loss to their families and to industry have become increasingly disastrous, for enforced absences of workmen hinder the war production program. Not only the military and industrial population but every man, woman, and child in the country is put under greater strain by the increased activities and anxieties which the war entails. The vast migrations of people brought about by the military and industrial requirements of the war also entail significant health hazards. Furthermore, the need for medical men in the armed forces depletes the number available for the care of civilians and demands greater knowledge on the part of laymen concerning ways to keep well and greater vigilance by the community in matters of health. Each of these factors has increased the responsibility of science teachers, for an ever greater number of persons must be helped to understand the scientific facts about health and disease, know how to protect their own health and that of their families, and support and participate in measures to improve the health of the community.

THE RECENCY OF MEDICAL SCIENCE

Health education has additional responsibilities, for knowledge and attitudes of lay-

* This article and a sequel, "Activities Useful in the Study of the Maintenance of Health," were in part based on material in the files of the Bureau of Educational Research in Science, Teachers College, Columbia University, especially upon monographs by John Urban and Marion Richter *(Suggestions for Teaching: Communicable Diseases)* and by Everett A. Manwell *(Suggestions for Teaching: The Physiological Interchange of Materials and Energy)*. Material was also drawn from Mr. Manwell's as yet unpublished Ph.D. dissertation, *Health in High School Science*.—Ed.

men lag far behind the scientific accomplishments of modern medicine. Medicine has realized many dramatic beneficent achievements for the welfare of man. Yet, it is only within very recent times that there has developed a science of health in the sense that there is available an effective working knowledge of health—the ability to prevent, control, and cure some of the major diseases that previously killed millions of people. The road to medical science is a long one that began in ancient Egypt, but it is somewhat startling to recognize that an actual science of health came into being only a very short time ago. Only since the nineteenth century have people known anything about the germ theory of disease and about the theory of immunology. Knowledge of the causes and control of deficiency diseases and knowledge of the life-saving properties of specific chemotherapeutic drugs, such as arsphenamine, sulfanilamide, and sulfapyridine, were attainments of the second and third decades of the twentieth century; and new findings in these fields are coming forward daily to push back the boundaries of death. The nature of the physiological functioning of the human organisms—of the process by which there is maintained a selective and balanced exchange of materials and energy with the external world—has been described by contemporaries. In the meantime the medical profession has grown in stature and responsibility, and medical education has been greatly improved. It is because of the recency of these developments that the vast potential contributions of health education to individual and community health are just now being recognized.

ELEMENTS OF A HEALTH EDUCATION PROGRAM

A comprehensive health education program includes both individual and community health problems. Its point of departure may be the scientific generalization that the human organism maintains itself by a selective and balanced exchange of materials and energy between itself and the external world. The development of this generalization involves teaching what scientists know about the processes of the circulation of the blood, digestion, and respiration in bodily health; about foods that are nutritious for bodily growth and repair and foods and drugs that are to be avoided. Health education extends beyond personal hygiene and health practices into an analysis of the factors influencing the choice of a physician and the quality and quantity of available medical care. It also comprises study of the preventive and protective measures administered by public health authorities and the nature of the communicable diseases that require community control.

All these health issues are significant subject matter for science teaching, for they affect the major social relations of an individual: his participation in family life, in the economic order as producer and consumer, and in the political world as a citizen. A successful handling of health issues through science courses will enable students to use science for personal and social improvement and will promote more sympathetic and intelligent collaboration with experts on medical care and public health.

THE FUNCTIONING OF THE HUMAN BODY

The human organism obtains energy-yielding food and oxygen from outside the body, uses them in its activities, and discharges the decomposed products as wastes. During this process of interchange, the human organism is able to maintain persistent stability through its internal activities, which enable it to remain in a fit state for continued action, or to be made ready for special emergency efforts should critical situations arise. Most important in the process by which the human body maintains internal stability in the face of conditions that might hamper or be destructive is the constant character

TABLE I

MAINTENANCE OF STABILITY OF BLOOD AND LYMPH *

A. Substances entering blood and lymph	*B. Effect of increase of A*	*C. Effect of decrease of A*
1. Products of digestion and absorption		
(*a*) Simple sugar (mostly glucose) carried in solution in plasma (0.1–0.15 per cent)	Storage as glycogen and fat excretion; chiefly through kidneys	Withdrawal from storage
(*b*) Amino acids carried in solution in plasma	Repair and growth of tissues Deaminization, excretion of nitrogen, chiefly through kidneys, and storage of remainder as glycogen	Breaking down of tissue proteins
(*c*) Fat carried as emulsion in plasma	Storage Excretion	Withdrawal from storage
(*d*) Vitamins A and D in fat? B and C in plasma?	Storage of A and D	
(*e*) Water in plasma	Storage in tissues Excretion chiefly through kidneys	Thirst and ingestion Withdrawal from tissues Excretion of water
(*f*) Inorganic salts carried in solution in plasma	Thirst and ingestion of water Absorption of water from tissues Excretion	Eating salt
2. Substances from inspiration		
(*a*) Oxygen carried chiefly in combination with hemoglobin; some in solution in plasma	Decrease in respiratory rate and depth (in balance with carbon dioxide)	Increase in respiratory rate and depth
(*b*) Nitrogen carried in solution in plasma	Excretion in expired air	Absorption from inspired air
3. Products of metabolism		
(*a*) Carbon dioxide carried in chemical combination with some sodium and potassium of hemoglobin plasma	Increase in respiration Excretion through lungs, some excretion through skin and kidneys	Decrease in respiration
(*b*) Other wastes nitrogenous, sulfates and phosphates	Excretion, chiefly through kidneys	
(*c*) Acids	Combination with sodium and potassium ions Excretion through lungs, kidneys, skin	
4. Formed in body		
(*a*) Red corpuscles	Destruction	Formation of new cells
(*b*) White corpuscles	Gradual destruction	Secretion
(*c*) Hormones	Changes in metabolism Excretion	Changes in metabolism
5. Foreign substances		
(*a*) Microorganisms carried in suspension	Increase in number of white corpuscles	
(*b*) Foreign proteins	Formation of antibodies	
(*c*) Toxins	Excretion	
6. Heat	Circulatory adjustments	Circulatory adjustments

* Devised by Anita D. Laton, San Jose State College, San Jose, California.

of the circulating fluids of the organism, especially the blood. This fluid-matrix makes possible the steadiness of body temperature, which releases the human organism from the limitations that might be imposed by seasonal changes. The steadiness of the mild alkalinity of the blood and the stability of the sugar concentration of the blood are likewise maintained by the body's effective regulatory processes. Table I illustrates the manner in which internal stability is maintained.

Although the human body has its regulatory internal processes which enable it to maintain stability, these are in the last analysis dependent for their functioning upon the external environment. From the environment are derived food and oxygen which provide the body's fuel, permitting the expenditure of energy and sustaining growth. The environment largely determines also the nature of the activities of the human organism, its work and play, and so fixes the amounts of energy that are expended. The body's physiological functioning may be disturbed by malnutrition, by disease-bearing microorganisms, by foreign proteins, by mechanical injuries, by the ingestion of toxins, and by other factors as yet unknown. Health is fostered by adequate amounts of nutritious foods; by proper living and by working conditions which decrease the possibility of overfatigue, exposure to communicable diseases, allergies, and household and industrial accidents; by competence in knowing how to avoid harmful drugs and obtain correct foods; and by ability to obtain adequate medical care.

KNOWLEDGE MAKES HEALTH POSSIBLE

Fatalistic attitudes toward disease are passing, though they still linger in certain circles. Not long ago it was generally believed inevitable that children should be inflicted with communicable diseases such as measles, chicken pox, and scarlet fever; and their possible effects upon the later life of the children who survived them were not realized. Diseases that could not be cured by careful medical procedures were accepted as chronic. Such attitudes still survive where there is ignorance of man's recently acquired medical knowledge and skills, and where this knowledge is rejected because of some religious doctrine or traditional prejudice against physicians and public health measures. But medical science has lowered the death rate and extended the span of life. Through health education students may learn to understand many of the processes which underlie both health and illness; how some microbes and viruses can be isolated and serums prepared and how the human body defends itself against infections with the result that the effects of many communicable diseases can be predicted, prevented, and controlled; how diseases of malnutrition no longer defy comprehension because some vitamins are known and can be prepared synthetically and man's physiological reactions to them are becoming clear; how knowledge of the effect of specific drugs on the functioning of the human body is no longer dependent on hearsay and folklore but upon the results of carefully controlled scientific investigations that have changed man's theory and practice in the use of drugs; and how prediction based on knowledge of many functional diseases enables their prevention, control, and cure where previously recovery was largely fortuitous. It is true that present knowledge of the cause and cure of different types of diseases varies considerably. Some diseases are precisely defined and effectively controllable; others less so; some remain still unsolved. But no diseases are regarded as forever beyond control; those that are acknowledged as unconquered are not considered unconquerable.

It is because health education can inculcate this new dynamic attitude toward health that it has such excellent potentialities for serving individual and social welfare. The maintenance of personal health and the illness and death rates of

neighborhoods and communities depend upon individual and group attitudes toward the possibilities of prevention, control, and cure of disease, as well as upon the possession of scientific knowledge. Since there is every reason to expect man's increasing conquest of disease, health education is working in a favorable situation. Space limitations do not permit even a brief discussion of the advances made in all fields of medicine. However, three outstanding fields will be treated as of utmost importance in health education: the control of communicable diseases through knowledge of disease-bearing microorganisms and through immunology and advances in sanitation and other public health measures; progress in chemotherapy; and the knowledge of vitamins and hormones.

Control of Communicable Diseases

The decline of the death rate and the lengthening of human life in recent years may be ascribed primarily to progress in the control of communicable diseases, which was the major medical and sanitary development of the nineteenth century. The extent to which the death rate has declined through the conquest of epidemics is not generally realized. Its significance is grasped when one learns that in 1348 the Black Death killed 25,000,000 people in Europe, 2,000,000 of them in England alone or about one half of that country's population. In the early seventeenth century it twice destroyed one sixth of the population of London, and throughout the eighteenth century killed hundreds of thousands in southern Europe. Typhus destroyed millions of lives before its cause was discovered and brought under control. It is estimated that as late as 1754 every tenth person died and one tenth of all mankind was crippled or disfigured by smallpox. Cholera ravaged the cities of Europe and America in the nineteenth century. Typhoid and yellow fever also exacted fearful tolls [1:152–153, 164–169]

One by one during the nineteenth century, these and other epidemic diseases were checked. There is no cause for complacency, however. The twentieth century has seen one of the worst epidemics in human history, the influenza epidemic. This epidemic in 1918–1919 killed more victims in a few months than did all the armies in the four years of World War I. [2] Epidemics have as a rule been concomitants of wars, a fact which makes vigilance in the present situation imperative. But never before has man been so well equipped with scientific knowledge and techniques to combat the epidemics as he is at present. The germs of the major communicable diseases have been isolated, the source of infection traced, the agent and mode of transmission determined, and in some cases immunization methods devised. Protection through immunization is possible against smallpox and diphtheria, yellow fever and typhus, plague, cholera, typhoid, tetanus, and whooping cough. Significant progress has been made not only because the external agents of disease have been discovered but also because man's knowledge of the internal functioning of the human organism has advanced prodigiously. In addition marked advances have been made in techniques of sanitation, in purifying water supplies, and in other public health measures required for the control of communicable diseases.

In spite of this available knowledge, the problems of communicable diseases are by no means entirely solved. Against influenza, malaria, syphilis, tuberculosis, and dysentery, against the infections with streptococcus, staphylococcus, and miningococcus there has been no decisive immunization. According to the statistics of the United States Public Health Service during the fifteen-year period from 1922 through 1936 the total number of cases of fourteen common communicable diseases ranged from the lowest figure of more than 1,900,000 in 1925 to more than 2,990,000 in 1928, and was about 2,261,000 in 1936.

The fourteen commonest reportable communicable diseases during this period were chicken pox, diphtheria, gonorrhea, influenza, malaria, measles, mumps, pneumonia, scarlet fever, smallpox, syphilis, paratyphoid and typhoid fever, tuberculosis, and whooping cough. For diphtheria, smallpox, and typhoid fever, the diseases for which methods of conferring immunity are well established and accepted and utilized by the public, there had been a decrease in the annual number of cases reported. In all other diseases there was no persistent and marked decrease. This discrepancy may perhaps be accounted for in part by a stricter policy of reporting communicable diseases. But it indicates in a considerable measure as well that the known scientific methods of preventing these diseases are not used to the full, and that these scientific methods require considerable improvement and popularization. In the meantime the situation revealed by statistics shows the need for increased health education and, as a result, greater application of community resources to the solution of health problems in order that the benefits of scientific advance may be brought to the entire population.

Progress in Chemotherapy

Although knowledge in immunology has not advanced sufficiently to enable man to prevent some communicable diseases, chemotherapy is making rapid strides toward checking their ravages and effecting cures. From the time when the first specific agent was produced by Ehrlich for syphilis in 1910, there have been extraordinary achievements. Sulfanilamide and its derivatives, utilized and improved since the late 1930's, rank among the most important findings in medical history and open up vistas of successful therapeutics never previously conceived. Already the sulfa drugs have proved effective in the treatment of diseases caused by streptococci, such as puerperal fever, some throat infections, cerebro-spinal meningitis, mastoid inflammation, recurrent rheumatic fever; and gonorrhea; and pneumonia. The therapeutic achievements of penicillin and other anti-biotics which act upon the life processes of the bacterial cells, have been as dramatic as those of the sulfa drugs. There is every evidence that these cures are but the forerunners of many additional ones to come.

At the same time, great advances have been made in the study of the effects of drugs on the human organism that afford the basis for control of widely used drugs now known to have harmful results. These give a scientific basis for legislation, such as Federal pure food and drug acts, which attempt to regulate their sale.

Knowledge of Vitamins and Hormones

The twentieth century has likewise been distinguished by discoveries concerning vitamins and hormones. The science of vitamins and hormones has yielded phenomenal results in improving human health through knowledge of diet deficiency and of the diseases of the endocrines. Prior to the present century the very concept that disease resulted from a lack of specific substances in the diet or because of glandular function was neglected in medical theory. The vitamin hypothesis was formulated between 1912 and 1915. Because the prevalent frame of reference was still in terms of external agencies of infection, scientists were skeptical of Goldberger's controlled experiments, beginning in 1914, which proved that pellagra was not of bacterial origin but was caused by the absence of vitamins in the diet of the poor people of the South. Step by step his work was corroborated and finally came the evidence that the vitamin called nicotinic acid or niacin cured pellagrins. By 1926, the distribution of vitamins A, B_1, B_2, C, and D was known. Their absence in the diet was later demonstrated, and therapeutic treatment of consequent disease states established. Since then these vitamins have been produced synthetically and vitamin K, a defi-

ciency of which produces hemorrhages, and vitamin E, have also been isolated and made synthetically. Comparable advances have been made in the treatment of endocrine diseases, particularly since the discovery of insulin in 1922 by Banting and Best.

These discoveries have had great importance in the promotion of health. They have given a positive content to health education, for they point the way to prevention of ill health by proper diets and so augment man's control over disease.

HEALTH AND INCOME

There is a wide gap between what is known by the specialist and by the layman. Even after the diffusion of scientific knowledge there are many factors that impede its utilization. Consider nutrition. The alphabet of vitamins may be well known, but sociai-economic factors, themselves controllable, may nonetheless interfere with the application of this knowledge. It is estimated, for example, by Brigadier General Lewis B. Hershey that one third of the rejections of men as physically unfit by the Selective Service Boards were caused either directly or indirectly by nutritional deficiencies. [3] In a large measure these nutritional deficiencies cannot be ascribed to ignorance, or even to customary national or regional diets that were ill balanced, although these are significant in some cases, but is to be explained primarily in terms of undernourishment related to poverty. The 1941 Yearbook of the United States Department of Agriculture gives testimony to the fact that deficiencies in the consumption of protective foods are found chiefly although not exclusively among low-income groups, among families on relief, and among the many nonrelief families whose incomes and hence living levels are low. [4] In 1940 Dr. Thomas Parran, Surgeon General of the United States, declared that more than 40 per cent of the people of this country were undernourished and malnourished; and that almost half of the American people needed more milk and milk products, eggs, and certain fruits and vegetables. [5] Although niacin can be prepared cheaply by synthetic processes, there were in 1939 more than 100,000 active cases of pellagra reported throughout the United States, largely among the poor. In spite of the fact that the prevention and cure for scurvy have been known empirically since the eighteenth century, a recent outbreak of that disease was reported in one state, principally among families on relief, one half of whose children had been without milk for more than two years. [6]

The case of nutrition is merely illustrative. Comparable data can be marshaled to show that the same problem prevails in other fields of health. The National Health Survey undertaken by the Federal government in 1935–1936, which covered about 2,500,000 persons, showed a clear correlation between low incomes and high illness and death rates that must be ascribed to the living and working conditions associated with poverty. Among families on relief, disability from all diseases—disability is defined as the product of frequency of illness and duration—was more than 2.5 times as great, and disability from tuberculosis almost 9 times as great as among families with incomes of $5,000 and more. Moreover, with the exception of respiratory and infectious diseases, where the rate is about equal for all income categories not on relief, each upward change in income level is accompanied by a downward change in the amount of illness. [1:136–141]

These findings are important for the teacher of health because they establish the fact that an analysis of the problems of health necessarily involves reference to the larger problems of social security. Available scientific knowledge is not fully utilized and medical care has not kept abreast of medical knowledge because of economic factors outside the field of medicine. For this reason, persons interested in the maintenance of health must consider

these economic factors in their appraisal and handling of the health situation.

DECEPTIVE ADVERTISING

There are other factors besides poverty that check the utilization of advanced knowledge on the maintenance of health and the effective prevention and control of disease. The science teacher will find himself pitted against powerful vested interests that prey upon ignorance in the promotion of their patent medicines, foods, and cosmetics. In order to sell their products, these interests manipulate emotions and opinions of people in matters of health, with the most skillful devices available and with callous disregard of the effects upon the consumer. Control of this situation through legislation has been found necessary for the social good. The science teacher promoting health knowledge thus becomes involved in the problems of the meaning of food and drug laws, the manner in which they are enforced, and the health hazards which are still not touched by prevailing legislation.

He will find himself also involved in questions of preventive medicine, including the protection of the public by inoculation against some of the germ diseases. The theory of immunology can readily be popularized, and its validity proved on scientific grounds. But the science teacher's problems do not end there. He will be obliged to evaluate the conflicting claims of those who advocate voluntary and compulsory inoculation. Compulsory inoculations involve a theory of human relations and of social responsibility that runs counter to theories of individual rights that have been cherished in the past and are widely prevalent at present. Through a comparison of illness and death rates, he will attempt to determine whether education alone is sufficient to make a program of immunology against such a disease as smallpox, or whether education must be supplemented by compulsory legislation. The teacher will thus often be required not merely to prove scientific procedure but to justify social action.

Knowledge of the functioning of the human body in health and illness and of the causes of communicable and other diseases and methods of preventing them will have to be supplemented by an awareness of the needs of social control in the interests of the health of the community. Comparable questions will also arise in relation to the handling of the problems of quarantine, of sanitation, of inspection of foods and water, of control of smoke and dust hazards, of prevention of occupational diseases, and of industrial and household accidents. In all these cases, the teacher must be prepared to cope with disbelief based primarily not on ignorance of fact but on social outlooks. The teacher in health education devoted to the improvement of the health of the whole community will find the modifications of such attitudes within the scope of his work.

A POINT OF DEPARTURE IN HEALTH EDUCATION

Students take a normal healthy interest in their bodies and are concerned with keeping well. They will therefore be responsive to teaching in the field of health when they realize that the information to be acquired has vital application to their own health and to that of the members of their families. They tend to be interested particularly in those bodily processes whose malfunctioning is likely to harass them during the age period through which they are passing. They want information, for example, on methods of getting and keeping a good complexion and of preventing and treating embarrassing pimples and blackheads. Because common colds have repeatedly interfered with their activities and spoiled their fun, they can readily be interested in their avoidance and control. How to escape the pains of indigestion is a matter of some concern to many of them, so they are receptive to education on better food habits. Earaches, toothaches, sinus

trouble, and muscle aches, which are dismissed by some parents as growing pains, trouble them sufficiently to make them responsive to refutations of this fatalistic judgment. While students' interests may sometimes be initiated only by the desire to relieve a specific ache or pain, such interests can serve as a point of departure for a discussion of the wider aspects of the functioning of the human body, of the selection of proper foods and avoidance of harmful drugs, and of the problems of medical care and of public health.

Discussion on the radio and in the press on nutrition, on glands, and on allergy stimulates students' interest in these problems. Unable by themselves to judge what is true or false in the talk about vitamins, or what to believe about advertised vitamin preparations, or about the various foods for which special values have been claimed, they will look to the teacher for expert guidance, if they are encouraged to do so. Stories about " monkey glands " have made many of them curious about endocrine disorders. Some have observed the physical and psychological effects of goiter in a half-understanding way and are responsive when the mystery of these disturbances is dissipated by accurate knowledge. They want to be normal in weight in order that they will not be ridiculed for being either excessively overweight or underweight, and this desire can be used to good advantage in the teaching of correct health practices. Children are, in general, looking for acceptable patterns of behavior, and many will through effective health teaching see the value of setting up codes of conduct valid in terms of correct knowledge rather than in terms of traditional sanctions.

Questions Students Ask on Personal Health

The questions which students ask on the functioning of the human body and on personal health practices give considerable insight into their interests. The fact that many of them are naïve indicates the level at which the teaching of health must begin in order to be relevant to the interests of the students. They set the stage for the selection of problems that students will consider their own and will be motivated to investigate. Attention to students' interests tends to keep teachers close to students' needs and to lessen emphasis on a formalized curriculum. The following are samples of questions frequently asked in this area:

Are pimples caused by poor digestion? What is the cause and proper treatment of boils? How can athlete's foot be cured? Can birthmarks or moles be removed safely? Will the continued use of a hair-remover preparation lead to a skin disorder? What is the cause of loss of hair in a young man and what can he do about it? How can dandruff be treated and prevented?

What effect does diet have upon body odor? What should one do to reduce weight? What is the relative value of rye and white breads? Do certain foods cause cancer? What types of food should one eat when engaging in strenuous athletics? Is it necessary to eat seafood occasionally to insure that a sufficient amount of iodine is being taken into the body? Is constipation dangerous? Is the frequent use of laxatives habit-forming or dangerous in other ways? Do bicarbonate of soda and similar substances relieve indigestion?

What causes hardening of the arteries? What are the symptoms of high blood pressure? What relation has diet to high blood pressure? Does strenuous exercise harm the heart? How much sleep should a person get? Do throat sprays, lozenges, or cough drops have any protective effect against flu and colds? Are cold serums of any value in the prevention of colds? Why do colds often lead to more serious diseases? Will violet rays and sunlamps build up one's health? Does smoking stunt a person's growth? Does smoke inhaled into the lungs pass into the blood? Is smoking worse for girls than for boys; worse for young people than for adults? Are cigarettes more harmful than a cigar or pipe? What is the effect of alcohol on the human body? Is even moderate drinking harmful? What are the effects of a venereal disease? Is it true that there is danger of acquiring a venereal disease from the use of public facilities? Do sedatives affect the heart?

The Health of the Family as a Basis of Student Interest

As the child lives in intimate association with others in the family circle he is sensitive to the anxieties, economic stresses, and

griefs which ill health within the family brings in its wake. His questions concern, therefore, not merely his own aches and pains but the entire gamut of diseases that affect others in his family. If he acquires in a science class information that can benefit other members of the family and enable them to preserve good health, prevent disease, and cope more effectively with illness, he will be of service in his family and will thus attain prestige.

Students tend to be especially interested in acquiring knowledge of health matters that can be translated into action. Among the questions they ask on medical care are the following:

When shall a doctor be called?
What shall be done in an emergency before the doctor comes?
To what extent can household remedies and patent medicines be safely used?
Are periodic health examinations worth their cost?
Is it right to "feed a cold and starve a fever"?
Are enemas helpful?

Interest is easily evoked on the important questions determining decision on the choice of medical services, that is, on the relative competence of the medical profession and competing healing cults; on the use of hospitals, clinics, and dispensaries; and on related questions on the costs of medical care. The child adequately informed may sometimes play an important role in changing family attitudes and practices in these and other matters relating to health.

Interests and Questions on Community Health

There are many problems in community action on health and disease involved in public health legislation and engineering that are of significance to students in that they affect them and their families directly. For example, the scope and authority of the Federal pure food and drug acts have definite relevance to them because they have heard over the radio and seen in press advertisements so many exaggerated claims for cures that they are suspicious and want clarification. Students have heard of and have sometimes been affected by community regulations designed to prevent epidemics and to lower the incidence of communicable diseases, but usually they do not realize the significance of such regulations. Many of them have been immunized against smallpox, diphtheria, and sometimes other diseases; but often the processes by which the body resists disease and develops immunity, and the medical theory and experience underlying inoculation procedures have never been explained. Discussion of these problems can interest the student because the obscurities that have surrounded them may be dissipated.

Many students have been quarantined, or have seen others quarantined, when they have been stricken by communicable diseases, and they have sometimes resented such infringements upon personal freedom because the purposes were not clear and the need was not understood. The illness rate is high in many communities because dusts in mines and factories engender occupational diseases. Students can readily be interested in these situations and in measures of coping with them. When they can see the pertinence to their daily lives and to their very survival, they are responsive to information on the manner in which foods are inspected to prevent food poisoning and the ways in which water is tested and treated. In the present war situation their interest can readily be stimulated in the methods by which the health of their brothers and friends is being protected in the camps and on ships and battlefields, and the manner in which such medical services affect medical care for the civilian population.

Students' Misconceptions

Students have acquired information and attitudes on the functioning of the human body, on foods, on microorganisms, on medicines, on medical care, on inoculations, on sanitation, and on kindred questions

haphazardly from their associates and from the press and radio. These views are vague, uncritical, contradictory, and very often false. In order to discover the nature of these beliefs, an analysis was made of the views on health common among high-school students studying biology. [7]

It was found that misconceptions about foods, constipation, cosmetics, colds, indigestion, and other kindred matters were very common. The most widely held misconceptions on the functioning of the digestive system were that liquid foods are always more readily digested than solid foods; that most people need to have their intestines "cleaned out" occasionally with a laxative or enema; that constipation is an important cause of indigestion; that at least two bowel movements a day are essential to health; that indigestion is usually caused by too much acid in the stomach; that many foods which are digestible when eaten alone are indigestible when combined with others.

Many students overrated the food value of spinach, failed to understand that candy is a food and that fish is not a brain food, and did not understand the relationship between vitamins and deficiency diseases. Unjustified faith in mouth washes was among the common misconceptions held about mouth hygiene. There was little understanding of the necessity for ventilation. Among the other misconceptions widely held among the students tested were: that the most frequent cause of bow-legs is that babies are allowed to stand up before they are old enough to walk; that smoking stunts the growth of children; that smoking is an important cause of tuberculosis; that the remedies which are advertised for colds could not be sold unless they were really beneficial; that boils and pimples are caused by "impure blood"; that powder and rouge used on the skin tend to prevent it from "breathing"; and that yeast is effective in curing pimples.

Misconceptions similarly abound in the beliefs held by students in relation to the medical profession and to public health regulations. In every community there are groups with vested interests who inveigh against the medical profession. The fact that adequate medical care is difficult for low-income families to obtain makes many persons receptive to propaganda against medical men that distorts the realities of the situation. Likewise there are those who obstruct the passage and enforcement of public health laws and regulations and seek to lower the taxes which provide funds for the maintenance of public health services. These groups play upon ignorance and fear and engender misconceptions that often have disastrous consequences. The teacher will find some children bitterly hostile to vaccination, to diphtheria and scarlet fever inoculations because they have come under the influence of such groups.

The ambiguity and inaccuracy of the formulations of the views on health held by the students even when they are not completely erroneous underscore the need for health education. Many students are conscious of the fact that they are ill-informed and are responsive to more reliable information. Some may assert their misconceptions aggressively, and seek to defend them tenaciously, but this is only an expression of their insecurity. Cherished misconceptions can be dispelled by skillful handling of the classroom situation through effective presentation of authoritative information with the purpose of promoting competent handling of health situation by individuals and the community.

People are ordering their lives according to these misconceptions, hence there is an important educational problem for the science teacher. The questions, misconceptions and interests of his students will primarily determine the teaching objectives he will emphasize and the learning activities he will encourage.

REFERENCES

1. Stern, Bernhard J. *Society and Medical Progress.* Princeton University Press, 1941. See also *idem, American Medical Practice.* Commonwealth Fund, New York, 1945.

2. Smith, Geddes. *Plague on Us*, pp. 24–25. Commonwealth Fund, New York, 1941.
3. National Nutrition Conference for Defense. *Proceedings, May 26–28, 1941.* Government Printing Office, Washington, 1942.
4. U. S. Department of Agriculture. *Farmers in a Changing World*, p. 333. Government Printing Office, Washington, 1940. See also: U. S. Department of Agriculture, Bureau of Home Economics. *Are We Well Fed?* p. 18. Government Printing Office, Washington, 1941.
5. Parran, Thomas. "Nutrition and National Health." *The Technology Review*, 42:3, June 1940.
6. Parran, Thomas. "Nutrition: Its Public Health Aspects. New Light on Old Health Problems." *Proceedings of the Seventeenth Annual Conference on Milbank Memorial Fund, March 23–24, 1939*, pp. 27, 30. Milbank Memorial Fund, New York, 1939.
7. Manwell, Everett A. *Health in High School Science.* Ph.D. thesis, Teachers College, Columbia University, 1940. (Typed.)

SCIENTIFIC METHOD IN READING SCIENCE

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THE scientific method should be applied more widely to the reading of science textbooks and reference works. How many teachers of science know precisely what ideas their students are getting from the pages assigned and what methods of reading they are using? Knowledge of students' ability to comprehend and of their reading methods is basic to sound instruction in science.

The effective reader of science material may be expected to get the main ideas of paragraphs, whether specifically stated or inferred; to follow the sequence of steps in an experiment; to select and comprehend accurately significant details of definitions, laws, formulas, and scientific procedures. Moreover, he should be able to grasp relations among details and between main ideas and details, relate them to his own experience, and draw valid inferences and conclusions. He should have a precise understanding of common words used in special ways and of scientific terms, symbols, and formulas. He should also know how to read charts, figures, graphs, tables, maps, and pictures.

Only a very few standardized reading tests include exercises based on science material, and these tests may not include the kind of reading required in a particular class. For this reason the individual teacher, in order to obtain an understanding of the reading difficulties his class is actually meeting, will construct tests and exercises using passages from books that his students will be expected to read. These tests he will use, as a diagnostic and teaching device, to ascertain specifically his students' reading ability, difficulties, and methods.

Suggested steps in constructing an informal test of this kind are as follows:

1) Select from the text or reference books in use a unit of 250 to 500 words that the students have not yet read.

2) Decide on the technical vocabulary, main ideas, details, inferences, and conclusions that students should gain from the reading of the passage.

3) Ask one class to write freely the answers to questions that call for the understandings to be gained. These answers, representing typical errors, are a basis on which multiple-choice and true-false questions may be constructed.

4) Construct questions and exercises that will test whether students have gained the appropriate knowledge from the reading. These exercises may be made more diagnostic by making each multiple-choice response (except the correct answer) represent a different kind of error—for example, an answer that is correct but too

limited, a response that is irrelevant or too vague and general, and a definitely incorrect answer. These different kinds of responses will be noted in the sample test. For example, in Exercise A, 1, the first response is true, but it is not the most complete of the four statements; the second response is the best and most accurate answer; the third is far too general—typical of the kind of responses many students make to their reading; and the fourth is clearly wrong. Similarly, in Exercise A, 2, the first response is true as far as it goes but it does not go far enough; the second also is true but it is irrelevant and does not follow from the main statement; the third is the most complete and accurate response given; and the fourth negates the principle on which the chromatographic-adsorption analysis is based.

5) After the class has taken the test, have a discussion of the best responses and of the methods of reading employed by the students who read most quickly, accurately, and creatively.

AN ILLUSTRATIVE TEST

The following is an example of an informal test that any science teacher can construct:

READING A SCIENCE ARTICLE

Read the following article in the way in which you would naturally read similar scientific material. As soon as you have finished reading, write in the blank "Time" at the top of the answer sheet the figure you see on the board. Then turn over the article and write from memory the answers to the questions.

CHEMICAL ANALYSIS BY COLOR*

SIMPLE METHOD MAKES "SPECTRUM" OF A COMPLEX MIXTURE

By means of bands of color, adsorbed by columns of alumina, magnesia, precipitated chalk, or even powdered sugar, chemists can now readily separate the constituents of complex chemical mixtures that not long ago defied division. By the same simple technique they can also purify chemicals; determine the structure of molecules; concentrate such substances as vitamins, hormones, and pigments from extremely dilute solutions; identify and compare drugs, dyes, and food products almost instantly. Although still employed chiefly as a tool in the research laboratory, experiments are being conducted to adapt the method to the isolation, purification, and testing of materials in the chemical and drug industries.

This "new" technique, named chromatographic-adsorption analysis by the inventor, was first developed back in 1906 by the Russian botanist, M. Tswett, who was investigating the pigments in plant leaves. In his pioneer experiment, duplicated in principle in the photographs above, a chemist's dream was realized: the ingredients of a complex mixture were spread out for investigation like the colors of light in a spectrum. Still more amazing, they could be cut apart with a knife!

The reason for the separation of mixtures into distinct bands on an adsorption column is now considered to be this: molecules of different substances travel down a column of adsorptive material at different rates, depending upon their individual affinity to the adsorbent. Substances that have a strong affinity for the adsorbent travel down slowly. Substances that have less affinity travel down faster.

Tswett's simple but revolutionary method of chemical separation was little noticed for 25 years. In 1931 it came suddenly into prominence when Kuhn and Lederer passed carotene through an adsorption column and found that instead of being a simple substance it was made up of a number of substances.

From the separation of plant pigments, it was only a step to the isolation and purification of vitamins. Some of the first pure specimens of Vitamin A, for instance, were made by chromatography. Vitamins D, E, K, B_1, B_2, and C were separated and purified by this method.

Means were soon found to isolate bands of chemical substances that were colorless or very faintly colored. By using quartz tubes in place of glass, and viewing the column of ultraviolet light, many ordinary colorless chemicals were found to fluoresce with different colors.

Colorless Vitamin D_2 was isolated from fish-liver oils by means of an indicating pigment. Vitamin A, in a column, was detected by painting a streak down the column with the Carr-Price reagent, which turns dark blue in the presence of the vitamin.

ANSWER SHEET

Name.....: Grade..... Age.....

Time .....

PART I

What did the author say?

PART II

A. It is important to understand the main ideas of what you read. In each exercise below

*"Chemical Analysis by Color," *Popular Science Monthly*, 141:48–49, July 1942.

check the best, most complete, most accurate statement of the main idea.

1. By means of bands of color
   ..... (1) drugs may be detected
   ..... (2) chemicals may be identified and purified
   ..... (3) scientific experiments can be performed
   ..... (4) new elements can be created
2. The principle that underlies this color method is
   ..... (1) that substances have an affinity for the adsorbent
   ..... (2) that colors of light rays spread out in a spectrum
   ..... (3) that molecules of different substances travel down a column of adsorptive material at different rates
   ..... (4) that molecules have the same degree of affinity to the adsorbent
3. One of the most important applications of this color method is
   ..... (1) in the isolation and purification of vitamins
   ..... (2) in the separation of carotene into a number of substances
   ..... (3) in the manufacture of ultraviolet lamps with quartz bulbs
   ..... (4) in the improvement of human life

B. It is important to understand the important details you have read. Below are statements of important details in the passage. If the statement is true, according to the passage, put a plus (+) on the line at the left of that statement. If the statement is false, according to the passage, put a zero (0) on the line at the left of that statement.

..... (1) The technique described in this article was first developed in 1906.
..... (2) The new discovery immediately caused revolutionary changes in chemistry.
..... (3) Carotene was found to be a single substance.
..... (4) Bands of chemical substances that were colorless could not be distinguished.
..... (5) Vitamin D_3 was isolated by means of a certain pigment.
..... (6) In using the ultraviolet light method, quartz must be used.
..... (7) Substances that have a strong affinity for the adsorbent travel down slowly.

C. It is important to be able to answer questions about what you have read. Write the answers to the following questions using *only* those facts which are discussed in the passage and which help to answer the questions.

1. What is the name of the technique described in this passage?
2. Who invented this technique?
3. What does the technique enable chemists to do?
4. How was the technique used in the study of vitamins?

D. It is important to be able to draw conclusions from what you have read. If you think a conclusion below is probably true, considering the facts in the passage, put a circle around PT. If you think a conclusion is false, put a circle around PF. If you think the facts given in the passage are insufficient to allow you to make a decision, put a circle around the ?.

1. Chemical analysis by color has produced revolutionary changes in chemical methods. PT PF ?
2. Vitamins would not have been so rapidly isolated in pure form if the method described had not been invented. PT PF ?
3. The application of Tswett's invention was delayed by lack of funds ..... PT PF ?
4. The method will be used in research laboratories only... PT PF ?

E. It is important to know the exact meaning of words in a passage. In the exercises below check the word or phrase which means most nearly the same as the italic word in the sentence.

1. By means of bands of color, *adsorbed* by means of alumina, magnesia . . .
   ..... process of adhesion of molecules to the surface of solids
   ..... assimilated
   ..... molecules dissolved in a liquid
   ..... adopted
2. . . . who investigated the *pigments* in plant leaves.
   ..... paints and enamels
   ..... colorless substance
   ..... coloring matter
   ..... segments
3. *Molecules* of different substances travel down a column . . .
   ..... a compound of elements
   ..... a kind of mould
   ..... a small particle of dust
   ..... a unit of matter

PART III

(For last page of the test see quotation from Student G's paper on page .....)

In administering the test, the teacher reads the directions aloud while the students read them silently. The students

are then purposely left free to read as they ordinarily would, so that the teacher may learn about their customary method of reading a passage of this kind. The teacher records on the board in large figures the time in ten-second intervals. When a student has finished reading, he looks at the board and writes on his answer sheet the number he sees there, which represents the time in seconds he spent in reading the article. In the test illustrated here, the student is directed to answer the questions from memory. This, too, is a natural situation, for, in general, people read this kind of article only once and get as much as they can from their one period of reading. The directions, however, may be varied for individual students and classes. Sometimes it may be desirable to have the student go back to the passage, after he has read it as first directed, and then go over his answers to the questions, taking as long as he needs to find the correct answer to each question. Thus the limits of his ability to comprehend may be tested.

VALUE OF THE TEST

At least five kinds of valuable information about students' reading of science material are provided by tests of this kind: (1) rate of reading the kind of material tested, (2) power and habit of organization of ideas, (3) ability to grasp main points and related ideas accurately, (4) ability to draw reasonable inferences and conclusions, and (5) understanding of science terms.

Rate of reading of itself has no significance. Only when rate is related to comprehension does it have meaning. A too rapid rate is a disadvantage in reading difficult science material. In a group of seventy-six college students the range in time taken to read the passage was from 90 to 240 seconds, the median 180. The three who made superior responses in Part I and perfect scores in the objective-type Part II spent 200, 220, and 240 seconds respectively in the reading of the passage. Two were able to make almost perfect scores in 160 seconds; one made a perfect score on the objective-type questions in 90 seconds, though his freely written response was very brief. The majority of students making the lowest scores used less than 200 seconds in the reading of the passage. There were some students who read very slowly and still did not comprehend completely or accurately.

The student's power and habit of organization of ideas obtained from reading is clearly indicated by the freely written response to the question: "What did the author say?" In any class the range and variety of response will be very great.* A few cases will show concretely the kind of diagnostic information that may be obtained from this part of the "homemade" test:

Student A. Score on objective-type test—9 (highest possible score 21)
Time of reading the passage: 220 seconds
Freely written response, Part I: "By means of bands of color many chemical substances have been divided into various things, such as hormones, vitamins, etc."

Student B. Score on objective-type test—11
Time: 110 seconds
Response: "Mixtures of complex nature may be separated. Methods as to color, segments involved, etc., are analyzed."

Student C. Score on objective-type test—12
Time: 140 seconds
Response: "Summarized the discovery of chromatograph and briefly stated its value."

Student D. Score on objective-type test—16
Time: 100 seconds
Response: "A method of isolating the substances or parts contained within a unit had come into prominence although discovered in 1906 by a Russian, Tswett. Carotene, which was believed to be a single substance, was found to contain different units."

* Much more detailed description of the use of this kind of test may be found in the writer's *Exploration in Reading Patterns.* Chicago: The University of Chicago Press, 1942.

Student E. Score on objective-type test—21
Time: 120 seconds
Response: "He described the history and uses of chromatographic-adsorption as a method in chemical analysis."

Student F. Score on objective-type test—21
Time: 90 seconds
Response: "That chromatography was discovered in 1906 by Russian scientist Tswett and is now used for purification, analysis, and isolation of chemicals."

Student G. Score on objective-type test—21
Time: 240 seconds
Response: "The process known as chromatographic adsorption, first discovered in 1906 and revived in 1931, is a method of analyzing chemicals or drugs by separation into bands of color. Salts of various kinds and even powdered sugar have been used. The principle involved is that of varying rates of adsorption. Substances with little affinity for the reagent sink more rapidly in a column; substances with great affinity sink more slowly. Even colorless chemicals by the use of quartz tube and ultraviolet ray may be divided into bands and analyzed. Although primarily for use in laboratories at present, this process is already in some use in the chemical and drug field commercially and may prove equally important to isolation and purification of substances in practical work of the future."

In any class striking differences in clarity of thought and logical organization will be found. Student A, both in the freely written response and in the objective-type test, clearly showed her inability to comprehend the passage. She had picked up a few words and phrases without comprehending their scientific meaning or their relation to the process described. Student G, on the other hand, expressed in her own words the author's pattern of thought in a summary that had unity, coherence, and proper emphasis on the process. Similarly, each student, in his responses to this simple question, reveals a great deal about his reading method and his thought processes.

The student's ability to grasp main points and related ideas accurately can be studied further by noting his responses in Exercises A and B of Part II. Among the common errors noted were:

(1) a vague, general response instead of the more precise and definite one
(2) a partial response instead of a more complete and adequate one
(3) failure to grasp relationships, as that between the affinity of a substance and its rate of travel
(4) the overpotency of certain ideas, such as the statement about the separation of carotene, which some students raised to the position of a main point instead of putting it in its rightful place as an illustration of a main point
(5) the overpotency of the familiar, as, for example, in Question B, 2. "Revolutionary changes in chemistry" are so common that many students were carried away from the facts in this case by the emotional overtones in this statement.
(6) failure to make minor generalizations from details as one reads; for example, the generalization in B, 4 that was derived from two examples of separating colorless substances
(7) failure to note dates and figures carefully enough and to fix them in mind

The ability to draw reasonable inferences and conclusions and to realize when one does not have sufficient basis for generalization can be studied by means of Exercise D. By discussing the answers in class the students should obtain a clearer idea of the thought processes involved in the making of inferences and generalizations.

The student's understanding of scientific terms may be analyzed to some extent through his responses in Exercise E. Some of the errors in the interpretation of the meaning of words are:

(1) inaccurate perception and memory of new terms
(2) the choice of a dictionary meaning that is not correct in the context
(3) a vague and general, instead of a precise and vivid, idea of the word
(4) the choice of a word, similar in form to the test word, as its synonym

The most common error in this test was the choice of *assimilated* as the best meaning of *adsorbed*. Many students read

adsorbed (which was unfamiliar to them) as *absorbed* (which was familiar). It is quite possible that students may mark all the multiple-choice exercises correctly and still not really know the meaning of the test words. For this reason, students should be asked to write a paragraph or to talk freely about the key technical terms in order to be sure that they interpret them correctly.

INSTRUCTION IN READING

As well as yielding an understanding of the students' ability to read and comprehend science assignments, tests of this kind supply valuable instructional material in reading. The last page offers the individual student an opportunity immediately to analyze his reading method. These individual analyses of process supply excellent material for class instruction in reading methods. From the limited number of cases studied, there is indication that high-scoring students have better reading methods and are more aware of their reading methods than those making low scores. Compare, for example, the descriptions of reading method written by Student A and Student B: Student A wrote in answer to the request to "think back and try to describe the process you used in reading this article": "I just don't know. I merely, without thought of reading, went through the article." Other poor readers said they "read each word." Some went over the passage, depending on the repetition of mere rereading. They recognized the necessity for selecting important facts but had no method of judging which were important. In marked contrast to this unawareness of the process and lack of direction and purpose is Student G's answers to the questions on the last page of the test:

A. Now think back and try to describe the process you used in reading this article.

I read more slowly than I ordinarily read (1) because I knew I would be tested on the material involved in it, and (2) because I am not accustomed to reading much on scientific material, even though I am interested in it, because I have insufficient background for anything more that "popular" stuff. I read the whole first, noting that main points came at the beginning, details at the end. Then I reread to fix certain details in mind.

B. Answer thoughtfully and accurately.

1. Just how did you get the main ideas?

   By outlining main points in my mind such as name of process, principle behind it, etc.

2. Just how did you find and remember details?

   Linking them to main points. Relating them to each other.

3. What do you do when you read that makes it possible for you to answer questions?

   Concentrate. Try to figure out author's purpose, attitude, etc.

4. What do you do when you read that makes it possible for you to draw conclusions?

   See if anything author said or implied would justify the conclusion. Weigh the evidence.

5. How do you figure out the meaning of unfamiliar words?

   Relate them to each other. Use my knowledge of foreign languages. Sometimes pure guess work.

Other competent readers spoke of skimming first to ascertain the trend or structure of the article, in order to decide which ideas are most important. If necessary, these students reread sentences that seemed to contain the main ideas. In a mixed class of good and poor readers there is real value in having the most effective readers share with the class the methods that have proved effective for them. Although there is no one best method, poor readers may obtain many suggestions that they can apply to the improvement of their own reading.

Teacher-constructed tests of this kind may be used for appraisal and diagnosis of reading ability, and also for teaching more effective reading methods. They are a useful instrument in making the teaching of reading of science books and articles more scientific.

SCIENCE TEACHERS FOR THE FUTURE

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FREQUENTLY, during this emergency, secondary science administrators are aware of two alarming situations; namely, the depletion of science teaching staffs and lowering of the professional and teaching quality and quantity. This situation is not due to a single factor, but is the result of many well known causes. It is not the purpose of this article to deal with the contributing factors. The writer, however, wishes to call attention to one aspect which, in the future, will have a serious and adverse bearing upon the high school science teaching profession, as follows: The hundreds of young men and women who, under normal conditions, would be enrolled in our colleges or universities, either as undergraduate or graduate science students, are not being trained today. Obviously, this science teacher shortage will continue for some years to come.

It is essential, therefore, that we high school science teachers, make it a chief concern of ours to select and encourage secondary students having keen abilities and above average personalities to give serious and intelligent consideration to enrolling in college with the view to becoming science educators.

A consideration of this objective and practical ways of attaining it indicates the necessity for a guidance program. A program, in turn, involves planning toward a definite goal. After the basic plan has been organized, then effort must be continually directed toward putting its concepts or ideas to work.

To this end, attention is now focused upon a plan for organization and suggestions for activities which, if adopted by a large number of high school science teachers, may aid certain aspects of the above stated problem. The usefulness of this procedure lies in its ultimate value, rather than in service as a solution to present day problems.

Following is a list of suggestions, in addition to similar ones, in which teacher assistance may be given to prospective science teachers, recruited from the high schools:

Study students carefully to determine which of them have desirable qualities for becoming good science teachers. This study should include the use of intelligence tests, previous school records and personal observations resulting from the teachers day by day contact with students. An observation period of sufficient time should be used in order to make a careful diagnosis to determine the abilities, interests and personality traits of the individuals under study and observation. Emphasis should be upon quality rather than quantity. One talented student per school per year will finally prove more valuable to the profession than a number of inferior students.

When a decision has been reached, hold many conferences with the selected students. At the initial conference discuss with them the idea of their becoming science teachers. As many phases of the problem as possible should be presented for consideration.

After high school students have decided to become science teachers, their training should begin as early as possible. The teacher should make available opportunities for enlarging their scientific point of view beyond the textbook and classroom. These students should be given the opportunity to assist with laboratory preparations and activities throughout their high school career. They should become familiar with scientific equipment, supplies and

experimental work. Also, encourage this group to affiliate with science organizations. These should include local, state and national organizations. Scientific journals should be available to them.

Civic and social activities, both in the school and community, should be a part of the training of these young people. Likewise, valuable experience may be gained through summer and part-time work which deals with some phase of science.

Finally, the teacher should make contact with colleges and universities in an attempt to learn of various science scholarships available to high school graduates. Prospective students should be encouraged to become applicants for scholarships in accordance with their interests and requirements.

Results obtained from the above suggestions will be satisfactory or unsatisfactory depending upon the number of science teachers who participate in a program of this type. The better organized and operated these efforts, the more positive the results.

TEACHING THE SCIENTIFIC METHOD TO PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

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ONE of the most important objectives in teaching science in the elementary schools is the development of scientific attitudes and habits of thinking. This has been pointed out again and again by leaders in the field of science education. It is generally recognized that facts and skills, important as they are, should not be ends in themselves.

Today the world is faced with many grave problems which will become even more serious when the present world war ends. The need for men and women trained in the methods of science for solving these problems will be great indeed. These men and women of the future are the elementary school children of today. How are they being prepared for the job ahead? Are the teachers of today capable of the task?

Before a teacher can lead children to develop appropriate attitudes and habits of thinking, he must know not only what these attitudes and habits are and how to use them but, most important of all, he must have them himself. Scientific habits of thinking are not acquired by reading books, listening to lectures, observing demonstration lessons, memorizing lists of scientific attitudes, or watching other people solve problems. They can be developed mainly by frequent practice of the scientific method in the solution of specific problems.

A functional course in methods of teaching science in the elementary schools, if it is to develop desirable attitudes in prospective teachers, should operate around problems. The problems should be selected by the students themselves as a result of felt needs. Students should learn how to recognize problem situations and then proceed to solve them by the scientific method.

An example from one of the writer's classes is reported as an illustration of a procedure by which students can participate in the solution of a problem of their own choosing and possibly progress toward the development of habits of scientific thinking.

THE PROBLEM

The class had been discussing certain investigations on children's nature inter-

ests made by Mau, Finley, Downing, Trafton and others. The discussion finally gave rise to a request on the part of several students to conduct an investigation of their own. A committee was formed to suggest several problems and to work out a plan of procedure. The problem accepted by the class was: What are the reactions of elementary school children to live animals in the classroom? The following specific questions were formulated:

(1) What emotions do children display when observing live animals in the classroom?
(2) What questions do children ask when observing live animals in the classroom?
(3) What remarks and comments do children make when observing live animals in the classroom?
(4) To what extent do children retain the information about animals they read and talk about in their classes?

SOURCES OF DATA

The children selected for the investigation were members of a kindergarten class and a fifth grade class from one of the public schools in Paterson, New Jersey. The classes and their teachers were invited to visit the biology room of the college and observe the animals in their cages, aquaria, and terraria. The children were all city children and had had very little contact with real live animals. The living animals observed by the children were guinea pigs, snakes, toads, frogs, white rats, rabbits, salamanders, crayfish, clams, tadpoles, snails, goldfish, and a pair of mice with three-day-old babies.

PROCEDURE

The classes accompanied by their teachers visited the biology room separately. The pupils were allowed to move freely about the room and study any of the animals they cared to, while their teachers mingled with them, answered their questions and made suggestions for further study.

The college students making the study were seated at tables scattered about the room apparently absorbed in reading or writing and paying no attention to the children. As soon as the children had become thoroughly engrossed in observing the animals, however, each student began noting specific reactions and jotting them down on paper. The students had previously been divided into groups according to the reactions for which they were to look for in the children. One group noted physical reactions, while another paid particular attention to emotional reactions. One group recorded the questions asked by the children and another listened for remarks and comments. Some students selected the more aggressive pupils to observe, while others watched the shy and quiet children.

After the children had had ample time to observe all the animals, their teachers called them together and asked them to name the animals they had seen and to tell what they had learned about each one.

FINDINGS

Each group of college students prepared a composite report of their observations. These reports were later read to the class and discussed.

Physical and Emotional Reactions

Evidences of excitement

(1) There was much pushing and pulling as the children crowded around the cages.
(2) Some children ran back and forth from one cage to another.
(3) Their voices were high pitched and tense.
(4) They imitated the noises made by the animals.
(5) There were many exclamations, such as, "Oh!" "Ah!" "Let me see!" "Stop pushing!" "Get out of my way!"

Evidences of happiness

(1) The children laughed a great deal.
(2) They clapped their hands.
(3) They talked to the animals in friendly terms: "Hello, my fond friend." "Hello, Mr. Snake." "How are you, Froggie-woggie?" "I would like to take you home."

Evidences of sympathy

(1) "Don't touch it. You might hurt it."

(2) "How do they keep warm?" "Why do they cover themselves with the paper?" "The baby mice look cold."
(3) "Do they get enough to eat?"
(4) "Don't they hurt each other?"

Evidences of fear and its absence

There was very little evidence of fear. A few children were hesitant about going near the snake cage. Although the boys seemed to be more interested in the snakes than the girls were, only two girls showed fear. On the contrary the lack of fear was expressed in many ways.

(1) Some children tried to touch the animals through the wire.
(2) Some children had to be prevented from opening the cages.
(3) Most of the children pushed as close to the cages as they could.
(4) "Can I touch them?" "Take them out of the cages." "Can I have one?" "Here's my little friend, mouse." "Look at our friend snake." "Could I have one for a pet?" "If you come to my house I will take care of you."

General Questions Asked by the Children

"How big do they grow?" "Is the snake alive?" "What do they eat?" "Who feeds them?" "Can he open his mouth?" "How old are they?" "Do those things [salamanders] swim backwards?" "Do you experiment with them?" "Which is the mother mouse?" "What came out of the snake's mouth?" (Referring to tongue). "Do they lay eggs?" "Suppose the fish went near the salamander, then what?" "How were they caught?" "Do they eat the paper?" "If you cut the snake in half will it still live?" "What is that green stuff?" (Referring to aquarium plants). "What would they do if you let them out?"

Remarks and Comments

"Make them move." "They look like baby rats." "They are too small for baby rats." "Rats have long tails." "They look like Snow White and the Seven Dwarfs." "They don't have long tails." "They even eat mouses." "They haven't any ears." "See how they dive." "Look at that lizard." (Salamander). "Here's a baby lobster." "I like the little ones best." "They look like submarines." "Here's my fond friend the rat." "There's father mice." "Look at the horns on that thing." (Snail). "Is that what a snake looks like? I thought they were much fatter."

Recognition

Although the kindergartners had heard stories and seen pictures of tadpoles, none of them recognized the live tadpoles when they saw them.

The tadpoles were called fish, frogs, and worms.

The kindergartners did not know that tadpoles developed into frogs, but the fifth graders had read about it.

None of the children recognized the guinea pigs although they had seen pictures of them.

Guinea pigs were called rabbits, mice, rats, squirrels, skunks, chipmunks.

Most of the children recognized the fish, mice, and snakes.

None of them knew the names of the snakes.

Crayfish were called lizards, baby lobsters, crabs.

None of the children recognized the salamanders, snails, or crayfish.

Most of the children knew that rats and mice ate cheese and bread and some said they ate paper.

None of them knew what the other animals ate.

CONCLUSIONS

The conclusions drawn by the prospective teachers were these:

(1) Live animals are a decided advantage in correlating real experience with reading.
(2) Live animals seem to mean more to children just as any real experience would in contrast to a manufactured situation.
(3) Live animals are a decided advantage over pictures and words.
(4) Children learn much more by seeing the real thing than by getting abstract ideas through reading.
(5) Children like animals for pets.
(6) Children seem to be more interested in what animals do than in what they look like.
(7) Children seem to be interested in what animals eat and how they are cared for.
(8) Both grades were interested but the kindergartners thought of the animals as their friends.
(9) Kindergartners seem to show more imagination.
(10) Watching real animals probably stimulated further interest in reading about them.

Obviously there are weaknesses in this study that might have been overcome had there been more time for a careful consideration of the whole problem. The study is not entirely objective. There was probably not enough evidence to warrant some of the conclusions drawn by the students. Their analysis of the data collected may not have been careful and accurate. However, the experience gained was probably of far greater value than any amount of reading they could have done about

children's nature interests. They probably gained as much from observing real children in a real situation as the children gained by their real experience with real live animals. An appreciation of individual differences and of how children react in a given situation was impressed upon them far more effectively than any classroom demonstration, recitation, or lecture could have done.

These students had selected their own problem; planned their own procedure; gathered, classified, and analyzed their own data; and drawn their own conclusions. In other words, they were on the way to solving problems by the scientific method. The experience gained by a practical application of the method of science in solving a problem made the study well worth while. Through this experience they should be better fitted to help children develop scientific attitudes and habits of thinking.

THE EDUCABILITY OF ADOLESCENTS IN INDUCTIVE ABILITY

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THE problem was to determine the educability of adolescents in inductive ability. The term *adolescents* refers specifically to the 240 general biology pupils of the sample, and *inductive ability* is restricted to the abilities measured by the particular tests used in the study. The mental process of induction is intricately associated with the mental activities which function in the application of the scientific method [1]. Experts are agreed on objectives in secondary-school science, which are predicated upon successful growth of pupils in understanding and use of the scientific method [2].

The experiment was conducted in the Johnstown High School, Johnstown, New York, and in these schools in Albany, New York: Albany High School, Philip Schuyler High School, and Vincentian High School. The organization is shown in Table I.

TABLE I

ORGANIZATION OF EXPERIMENT

School	*Teacher*	*Number of Pupils in Classes* *Experimental*	*Control*
I	1	30	25
	2	29	34
II	3	19	22
III	4	22	23
IV	5	38	27
		138	131

The testing and instructional schedule for the classes was as follows:

Tests and Instruction	*Completed*
Preliminary tests	October 4, 1940
Fifteenth instruction period	January 31, 1941
Thirtieth instruction period	May 23, 1941
Final tests	June 7, 1941

THE SCALES

The tests used in the experiment were these: Henmon-Nelson Tests of Mental Ability [3], L. L. Thurstone's Tests of Induction [4], and two specially prepared instruments, called the Judge Conclusions Test and the Direct Conclusions Test.

At the beginning of the experiment all pupils were given the Henmon-Nelson Test of Mental Ability, Grades 7–12, Form A, to serve as a basis for differentiation of pupils into three ability levels. The reliability of the test for the tenth year is .900.

The titles of the Thurstone induction tests are: Letter Grouping, Marks, and Number Patterns. The estimated reliability of the tests by the split-half method is .87 and the estimated validity is .53. The ability measured may be described briefly as that of sensing patterns or finding

the rule by which nonverbal materials are organized.

The Judge Conclusions Test was designed to measure the ability of the pupil to identify conclusions as (1) complete, (2) incomplete, (3) beyond the data, or (4) false. During the school year 1938–1939 twelve condensed reports of experiments [5] were given 150 tenth-year biology pupils who were directed to study the data carefully, to accept all the data as true, and to write a conclusion. The investigator selected 156 items as being representative of the four categories for a provisional form of the test which was used in a rehearsal of the experiment in 1939–1940. A jury of four biologists independently placed each item in one of four categories and 59 items were discarded because of lack of agreement. The remaining items composed the test which was used in 1940–1941. The frequency per cent response on each item was found for the pupils of the highest and lowest groups, and nineteen items were discarded by inspection as having low discriminating power. The high group of the sample of 428 pupils included the pupils who had the highest 25 per cent of correct responses, the low group included pupils with the lowest 25 per cent of correct responses. The probable error of the difference of the means of the high and low groups was calculated for the items and the ratios of mean difference and probable error of difference of means was determined. Seventy-three of the items had ratios of 4 or more. The five exceptions had ratios ranging from 1.92 to 2.48. The estimated reliability of the test by the split-half method and corrected for length by the Spearman-Brown formula was .903.

The Direct Conclusion Test was prepared by the following procedure. Fifteen items [5] were tested in 1938–1939 to determine the suitability of each item to elicit direct responses from the pupils. Six items were discarded because the range of conclusions was small. Nine items of brief experiments were used in the test. The pupils were directed to read the description of the experiment carefully, to consider all data as true, and to write a conclusion on a 2 x 6 card. Each response was evaluated on the basis of three categories: (1) complete, (2) beyond the data, (3) false. A guide was made by examining more than 400 responses for each item and placing responses under subcategories of the three main categories. Assignment of values to the subcategories ranged from 0 to 5 and was entirely subjective. The scores on the three categories were not combined into one score but were carried independently, for every method of combination which was tried obscured the picture. The responses were graded independently by three scorers. A comparison of their scores was made on three items. Coefficients of reliability calculated from more than 300 initial responses of both experimental and control pupils, were .947, .950, and .930 respectively.

INSTRUCTION IN INDUCTIVE PROCESSES

After the preliminary testing, the experimental classes were given a brief statement on the scientific method with special consideration of the subordinate concepts which are involved in the formulation of the hypothesis or generalization. The instructional material consisted of briefs or résumés of thirty biological experiments. Sources of this material include: *Journal of Parasitology, Journal of Nutrition, Botanical Gazette, Journal of the American Medical Society,* the Yearbook of Agriculture for 1939[6], and Interpretation of Experiments [5]. To secure as much uniformity as possible, each teacher was given the following suggestions:

A. Distribute data sheets to each pupil.

B. Direct the pupils to read the experiments carefully, to consider all facts as true, to consider the experiment as controlled, to identify the experimental factor, and to write a conclusion. (The conclusion is written on paper other than the data sheet.) Time limit is ten minutes.

C. Collect the written conclusions, but not the data sheets.

D. List controlled and experimental factors on blackboard. Write satisfactory conclusion on the blackboard. (The analysis of the experiment and formulation of the conclusion is a cooperative task of the class and the teacher.) Time limit is ten minutes.

E. Select conclusions at random and place on blackboard. Through discussion of class, judge the conclusions on the basis of completeness, accuracy, and the degree to which the conclusion goes beyond the data. Time is limited by the length of class period. (The time varied from fifteen to twenty minutes.)

THE DATA

Because the classes of the five teachers were not all organized on the basis of ability levels, the experimental and control samples were regrouped on the basis of raw scores of the Henmon-Nelson Tests, a distribution of the raw scores was made, and by trial and error two points were selected which roughly divided the sample into high, middle, and low samples. The high, middle, and low samples are referred to as A, B, and C samples respectively. Lower-case letters x and c denote samples as either experimental or control: for example, Bx indicates the middle experimental sample. Cases were discarded by the random number technique until each subsample contained 40 pupils; 29 cases were discarded.

The hypothesis that the true means of the experimental and control groups with samples A, B, and C were equal at the beginning of the experiment was tested by the t statistic, and the F test served as a basis for accepting or rejecting the hypothesis that initially the true variances of the subsamples were equal. The hypothesis of equal initial means and variances was accepted with the exceptions indicated in Table II.

TABLE II

SAMPLES FOR WHICH THE HYPOTHESIS OF EQUAL INITIAL MEANS AND VARIANCE WAS REJECTED

	Direct Conclusions Test			*Thurstone*
Sample	*Complete*	*Beyond*	*False*	*Induction*
Ax,Ac	F=1.730			
Bx,Bc		F=1.874		t=2.705
Cx,Cc		F=1.952		

To determine whether the control subsamples made significant gains in inductive abilities during the experiment, the hypothesis that the initial and final means were equal was tested by the t statistic. The hypothesis was rejected for the means on the Judge Conclusions Test and Thurstone Induction Test. Sample Bc made significant gains on the Beyond and False categories of the Direct Conclusions Test and on the same test the Cc sample made significant gains on categories Complete and False.

TABLE III

SAMPLES IN WHICH THE HYPOTHESIS OF EQUAL FINAL MEANS WAS REJECTED; VALUES OF t

	Judge	*Direct Conclusions Test*			*Thurstone*
Samples	*Conclusions*	*Complete*	*Beyond*	*False*	*Induction*
Ax, Ac	2.437	3.911	—3.700		
Bx, Bc	2.744	2.740			2.014

The basic assumption was made that without the instruction and practice in induction, the experimental group means on the inductive scales would not exceed the respective means of the control samples. The hypothesis of equal final means was rejected as shown in Table III. For the Beyond category, lower scores indicate more caution. The superiority of the Bx sample on the Thurstone Induction Test was apparent initially as well as finally, and significant mean gain is not inferred.

The means of the entire x sample were compared with the means of the total c sample initially and finally by means of the critical ratio.

The critical ratios of the mean difference of the x and c means and the standard errors of the differences are shown in Table IV. Initially, the hypothesis of equal

means was accepted on the Henmon-Nelson Test, Judge Conclusions Test, and Direct Conclusions Test, but not for Thurstone's Induction Test. The chances are slight that the final mean differences favoring the experimental sample are due to chance, Thurstone Test excepted, and the inference is that the mean differences are due to the instruction given the experimental group.

Conclusions from the Data of the x and c Samples

Considering the entire experimental sample, the instruction resulted in meaningful gains in the ability to classify conclusions, to write more complete conclusions, to write with less rashness, and to make fewer statements directly contradicted by the data. Initial difference in the ability to sense patterns (Thurstone Induction) which favored the experimental sample makes an inference in this respect undesirable.

TABLE IV

CRITICAL RATIOS OF THE MEAN DIFFERENCE OF THE EXPERIMENTAL AND CONTROL GROUP MEANS AND THE STANDARD ERRORS OF THE DIFFERENCES

	Henmon-Nelson	*Judge Conclusions*	*Direct Conclusions Test Complete*	*Beyond*	*False*	*Thurstone Induction*
Initial C. R.	—0.29	—0.29	0.94	—1.03	0.02	1.5
Final C. R.		2.13	3.31	—3.0	1.5	1.7
Initial chances in 100	62	62	79	85	51	94
Final chances in 100		98	100	100	93	96

CONCLUSIONS

The conclusions are presented under two headings, (1) the conclusions inferred from the analysis of the several subsamples, and (2) the conclusions inferred from the analysis of the final experimental and control samples.

Conclusions from the Data of the Subsamples

The instruction in induction was effective—effective gains are those gains which have statistical stability—in increasing the ability of the Ax and Bx subsamples to classify conclusions as being complete, incomplete, beyond the data, or false. The direct conclusions of the Ax and Bx subsamples were more complete than those of the Ac and Bc subsamples, and the conclusions of the Ax group were more cautious than those of the Ac subsample. In all other respects the consistent differences favoring the experimental subsamples were not significant.

BIBLIOGRAPHY

1. Downing, E. R. "Elements and Safeguards of Scientific Thinking." *Scientific Monthly*, 26:231–232, March, 1928.
2. National Association for Research in Science Teaching. Committee Report. *Science Education*, 22:225, 226, 230; October, 1938.
3. Henmon, V. A. C., Nelson, M. J. *Henmon-Nelson Tests of Mental Ability, High School Examination Grades 7–12. Form A.* Houghton Mifflin Company, New York, 1935.
4. Thurstone, L. L. *Tests for Primary Abilities.* The American Council on Education, Washington, D. C., 1938.
5. Barrows, E. M., Frutchey, F. P., Price, V. W., Snyder, L. H. and Tyler, R. W. *Zoology Test II, Interpretation of Experiments, Provisional Forms.* The Coöperative Test Bureau Service of American Council on Education, New York: 1934, 1935, 1936.
6. United States Department of Agriculture. *Food and Life, Yearbook of Agriculture, 1939.* U. S. Government Printing Office, Washington, D. C., 1939.

SERVING CLEVELAND AND THE NATION THROUGH SCIENCE TEACHING *

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THE science teacher today looks with great concern upon the ills of the war-torn world. He knows that a better world can result when people learn to apply scientific method and procedure to the conflicting forces of everyday living. He knows that when people think rationally, want and fear can be banished and man can gain such control over the forces of nature as to promote better living.

SCIENCE INSTRUCTION HELPS FREE PEOPLE FROM WANT AND FEAR

The science teacher knows all this because he has seen want conquered through the application of scientific principles to agriculture and to industrial explorations of minerals, materials, machines, and sources of energy. He knows all this, too, because he has seen how science has freed man from the tyranny of fear and superstition with resulting improvement in the status of civilized people.

Hence, the program of science instruction in Cleveland has been aimed first of all at the promotion of critical or better thinking. When pupils in science classrooms learn to apply the steps of the scientific method to the problems of everyday living, such thinking should result. Critical thinking can insure peace and freedom from want and fear.

* Mr. Baker's article is the second of a number of reports on science plans and programs in individual schools and school systems. The first of the series (Brandwein: "Four Years of Science") appeared in the February issue. Comments from readers are invited to the end that SCIENCE EDUCATION may assemble a collection of first-hand accounts of what is being done and planned to meet conditions during and after the war.—Ed.

SCIENCE INSTRUCTION HELPS TRAIN PUPILS TO COPE WITH CURRENT ISSUES

A program of instruction in science to be functional cannot lag behind the impacts of the current social scene. These impacts should focus the attention of teachers and pupils upon issues that are vital.

Such focusing of attention has come about through two recent happenings. First, of course, was the entry of the United States into this war. Second was the release of the report *Science Teaching for Better Living* [1].

Even before the Japanese attack on Pearl Harbor, academic presentations in science were giving way to a more functional program. As indicated in *Science Teaching for Better Living,* the program was being directed toward greater emphasis upon scientific method and the development of critical thinking. Also emphasized were the promotion of better health, the attainment of wider recreation, the securing of greater safety, the establishment of wiser consumer attitudes, the conservation of natural resources, and the orientation of pupils to more effective work.

Additional modifications after Pearl Harbor have resulted in a further functionalization of the science program. It is being geared to two issues—the winning of the war and living in the peace to follow. Hence, there is increased emphasis on such issues as the development of health and physical fitness, the promotion of victory gardening, safety and first aid, conservation, and the elimination of waste. Such dynamic problems of living as those associated with communication, transportation, and preparation for living in the coming air age are being stressed also.

SCIENCE INSTRUCTION CAN PROVIDE TRAINING WHICH IS VITAL TO THE WAR EFFORT

As a result of these two impacts—the entry of the United States into the war and the release of *Science Teaching for Better Living*—a committee restated the Cleveland science curriculum for grades 7, 8, and 9. The seventh grade curriculum now relates largely to the health objective, but health materials also permeate the science work of grades 8 and 9. A gardening program also carries through all threee junior high school grades. Red Cross First Aid is now an integral part of the seventh grade program. New units and materials include increased attention to scientific methods, conservation, and meteorology. Other aspects of the curriculum are directed toward the development of air-mindedness.

A health series of radio broadcasts for junior high school science classes, entitled *Science and the Doctor*, has been developed with the help of the Cleveland Academy of Medicine. These programs, too, reflect the impact of the present emergency, as indicated by the titles of some of them:

(1) Conserving Your Teeth
(2) Tramp, Tramp, Tramp—Keeping the Feet in Good Condition
(3) Health Problems of the Army
(4) Chow
(5) Ready! Exercise
(6) Getting Along with People
(7) Controlling Communicable Diseases in the Army

The same impacts have also affected the curriculum in science in the senior high schools. Experimental materials developed over the past three years have been reassembled so that all new health units are grouped in biology. These materials were released in a syllabus in January, 1943. Thus the teaching of biology has been geared to the health objective as outlined in the High School Victory Corps program, as these titles suggest:

(1) Use of "Scientific Method" in Evaluating Health Advertising
(2) Our Common Enemy—the Cold
(3) Tuberculosis—the Problem of Youth in the Community
(4) The Vitamins—Eating to Live
(5) Better Teeth for Better Health
(6) Modern Techniques in First Aid
(7) How the Forces of Daily Life Affect Mental Health

In another syllabus released in January, 1943, additional experimental materials have been grouped for senior science, physics, and chemistry. Again the impact of the war is apparent. Here are found such suggested additional units as Greater Safety in Everyday Life; Synthetic Textiles; Fire Prevention in Peace and War; Metals for Airplanes; Meteorology; Civilian Air Raid Defense; Getting the Most Out of Fuels by Smoke Control; How May We Protect Ourselves in Chemical Warfare; George Washington Carver; and How Chemurgy Is Related to Conservation.

Insofar as has seemed practical and possible, suggestions from the U. S. Office of Education, the Civil Aeronautics Administration, and the War Department have been followed. Hence, two preinduction courses have been developed as follows:

(1) Mathematics and Physics of Aeronautics
(2) A Course in Communications consisting of:
    (a) Radio Physics (science department)
    (b) Radio Shop Practice (industrial arts department)

SCIENCE TEACHERS TODAY ARE PREPARING FOR BETTER CLASSROOM SERVICE

Teachers of science in the junior and senior high schools have demonstrated an admirable willingness to cooperate in the gearing of instruction in science to the winning of the war. They have realized the importance of keeping abreast of the times in the rapidly changing fields of science. They see the need of getting up to date in the fields of industrial and physiological chemistry, aerodynamics, electronics, and radar science. Science teachers sense the fact, too, that they will need to know more about the relation of earth science (geology, conservation, astronomy) to

avigation, navigation, and global concepts.

Science teachers are being confronted increasingly with the assignment of teaching more than one of the sciences or of teaching a fused science course. While general science has been popular for some time in the junior high schools, only recently have such fused courses as senior science, physical science, consumer science, the mathematics and physics of aeronautics, and radio physics appeared in the senior high schools. Hence many science teachers are pursuing courses of a semi-technical nature that will bring them up to date in several of these rapidly developing areas of science. Science teachers have accepted the opportunity to take such courses as aeronautics, meteorology, navigation, aerodynamics, electronics, radio, and first aid. Local universities have sensed this temporary urge which teachers have for semi-technical training rather than for courses in the philosophy and methods of education. New courses of this nature have been organized for science teachers in Western Reserve University, Case School of Applied Science, Fenn College, Notre Dame College, and John Carroll University.

SCIENCE INSTRUCTION WHEN PEACE COMES

The war is not over. Hence the program in science for the next year or two should probably continue along present preinduction lines. When peace comes, new problems and issues will confront us. Many educators doubt if the anticipated Air Age will come as rapidly as has been predicted. However, it is apparent that people are becoming increasingly air-minded. Already the realities of the Air Age are being brought into the science curriculum to develop "Air-mindedness" in boys and girls. For example, a series of science broadcasts entitled *So You're Going to Fly* was given over the Cleveland Board of Education radio station WBOE by outstanding aviation authorities. That the air-mindedness objective was kept in mind is evidenced in such broadcasts as:

(1) Research in Aviation
(2) Safety in Air Travel
(3) The Future of Private Flying
(4) Civil Air Patrol Activities
(5) Advances in Airplane Manufacturing

A radio series called *Wings and Waves* was developed also to present materials pertinent to aeronautics and the rapidly expanding area of communication. The latest series of broadcasts for science classes is called *Science and the War Industries.* Ten of these broadcasts are related to industrial aspects of aviation.

Peace will come to a world greatly changed by science. Significant discoveries are being made in laboratories now engaged in research for war. These discoveries will make available new and improved materials and products.

The postwar world will have access to more powerful tools, tougher alloys, stronger steels, better aluminum products, harder abrasives, more ingenious automatic controls, and more useful plastics. Aircraft will be safer, homes will be finer, medical service will become more skilled, travel will be greater, and agriculture will be put on a more scientific basis.

When peace comes, the science program must keep abreast of these phenomenal developments. Science teachers will be challenged as never before to demonstrate through improved curriculum materials that a more intelligent consumption of goods and services can take place, health and safety can be established, natural resources can be conserved, and better adjustments to labor-saving machinery can be made. Finally, an increased knowledge of consumer science can bring us *better living.*

REFERENCE

1. National Committee on Science Teaching. *Science Teaching for Better Living.* National Education Association, Washington, D. C., 1942.

BIRD STUDY AS AN EDUCATIONAL PROJECT

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AT all levels of formal education there is need for individualization of project work to make possible certain desirable educational experiences. One of the most adaptable and successful subjects for independent study, rich with possibilities, is that of birds. The exceptionally good student in need of additional interests, the reticent pupil who needs an experience to foster self-confidence, the physically restless person who needs an out-of-door activity, the student with a trend toward interest in natural science, the inquisitive adolescent with newly awakened interests, the college student in search of stimulating recreation, and the research scholar seeking a challenging and vital problem on which to work will find a desirable subject in bird study.

Birds are in many ways the most convenient organisms with which to work in science. They are relatively easy to learn and study, and the number of different species one is likely to encounter in any particular locality is not great. Most problems would not involve over a hundred species. These can be learned progressively by starting with the rather small number of permanent and winter residents (some two dozen in most localities) and learning the migratory and summer species as they arrive in the spring and early summer. Fortunately, common names have been standardized so that none but specialists need to memorize the scientific names which offer a hurdle in the study of other groups of animals. Thus, one can learn such names as Rough-winged Swallow and Eastern Mourning Dove instead of *Stelgidopterx ruficollis* and *Zenaidura macroura carolinensis*. Excellent field guides, handbooks, and color plates are available to assist the student. Voluminous literature has been published for the amateur as well as for the serious student. Little equipment is needed, a pair of binoculars being the only necessity for good work; but there is no end to specialized equipment which one could utilize for detailed and advanced studies. Bird study can be pursued profitably all the year round, at any place, and at any time. Much progress can be made in brief intervals of time, and in a rather short span of time. Taxidermy is open to the manually gifted student. In addition to all of these advantages, there is probably no field of natural history which has proved to be so absorbing and fascinating and has had such a wide appeal as bird study.

Many projects of varying degrees of complexity and requiring various levels of attainment in skill are possible. Some simple problems require no technical training. A beginner can make a good start and contribute greatly to his own educational development. Once three school boys brought to the writer's laboratory a Florida gallinule which they had observed in flight and which had been killed as it struck a wire. They were curious to know about this bird. One boy in particular took a keen interest, and later requested permission to take the bird to his school, after preparation of a study-skin had been made, to show his class-mates. His teacher reported that for the first time in his school life this pupil was able to appear before his class and describe an experience. His awakened interest had triumphed over his usual shyness. Other children have broadened their social experience through leadership in school bird clubs. A good amateur can often make a distinct contribution to the science of ornithology. Recently a boy in South America was accredited with the honor of making one of the very few known records of the chimney swift in its winter territory.

The study of birds can be so organized as to illustrate a great many biological principles for purposes of instruction or to fur-

nish means for original investigations. Studies in migration, individual and social behavior, ecological relationships, populations and census tabulations, food and nesting habits, the life history of single species or individuals can be organized from data thus assembled. Methods of field and station observations, census taking, migration watching, bird banding and photography can be applied according to the nature and extent of the problem, the time available, and the locality of the project. Special provisions can be made to fit the circumstances of each case. Students who spend weekends on a lake or at a camp; off-campus students who live near some favorable habitat for bird life; school teachers in service carrying on studies *in absentia;* and students commuting to school can easily arrange a field project. Vacation visits or leisure time can be utilized in pursuing a program of bird study. Men in the armed forces have an opportunity to observe birds in many parts of the world, and in some cases can arrange to earn college credit for such an activity. For several years some of our commuting students in ornithology cooperated in a North American robin census by counting the robins on a circumscribed area in various sections of our region while travelling to and from the campus, and the resident students covered local populations on their way to class. When the instructor is licensed for bird-banding, qualified students make good and enthusiastic helpers. Portable traps can be loaned to the advanced students for independent banding in their own neighborhoods.

The writer has had undergraduate students carry out simple field problems in connection with course work in biology, ecology, and ornithology. One such study was made on "The Fall Bird Migration at the Mogadore Reservoir." The student who made this study later wrote a term paper for his English instructor entitled "Winter Birds of Stark and Portage Counties" which was sponsored cooperatively by the departments of English and biology. A student in general biology wrote a report on "The Riddle of Bird Migration." Individual projects in the writer's class in advanced ecology have produced such papers as "An Ecological Study of Birds with Reference to Population Numbers, Distribution, Migration, Associations, and Nesting Habits." An honor's thesis in zoology was prepared on "A Study of Local Bird Populations in Kent and in Warren, Ohio." To receive graduate credit in bio-ecology, graduate students are required to complete a supplementary field problem. Some of those which have been submitted are "Observations on Bird Populations in a Restricted Area near the Portage Lakes," "A Bird Population Study," and "Observations on the Summer Bird Residents of Kent State University Campus." A graduate problem conducted jointly by two students was entitled "A Bird Census in Braceville Township, Trumbull County, Ohio." Of the various field studies supervised by the writer, those on bird study have been among the most successful. The adaptability of bird study to circumstances and to the experience of the student has been chiefly responsible for this.

One of the great advantages in promoting bird projects not shared by other fields of zoology is its "carry over" value into later life. A study of birds often leads to a lifelong hobby. It trains one for leadership in teaching bird-lore to camp and school groups, bird clubs, scouts, and other youth organizations. It lays a foundation for teacher-preparation, for organizing and counseling Audubon clubs in the schools, and for personal enjoyment. It offers training in observation of nature. It is alive with the spirit of sport. Keen competition arises from the compilation of seasonal lists, migration lists, life lists, the recording of first arrivals, nest-finding, and the discovery of new and unusual records. Companionship with kindred spirits on the subject leads to enjoyable holidays together

on bird walks, cooperation on the Christmas bird count sponsored by the National Audubon Association, and the formation of local bird clubs. Some enthusiasts will later become affiliated with our national and regional ornithological societies. Many doors are open for the enjoyment of bird study after the more serious work has been completed and left behind. Some, on the other hand, may continue in the scientific aspects of ornithology and prepare for professional work in the expanding field of economic ornithology.

In the organization of bird study projects, certain general procedures should be followed. A specific problem should be formulated according to the experience and interest of the student and to the amount of time available for the study. The published literature on the subject should be reviewed, and a certain amount of background reading on bird life undertaken. Beginners should devote the first year to learning the local birds and becoming familiar with them. Some students will already have a good foundation from previous field experience. These should have a definite goal or a set problem, although this may at times be a rather broad goal, especially for their initial study. The common practice of simply compiling a checklist should be discouraged. Inasmuch as possible, cause and effect relationships should be sought and constantly kept in mind. [1] Complete and accurate field observations should be recorded in a note book. Whenever possible quantitative data should be secured. Field observations should be made frequently and at regular times. For some studies, the same territory should be covered with consistent thoroughness over and over again. One should be constantly on the alert for observations and interpretations. Besides reconnaissance observations, feeding stations and nesting boxes may be utilized for study, and traps may be set for banding purposes. Much has been written on this subject to assist the student and the instructor and there is no need for repeating details here. *A Field Guide to the Birds* by Peterson has been a very successful handbook. [2] *Natural History of the Birds of Eastern and Central North America* by Forbush and May is recommended for general reference and for its collection of fine color plates. [3] *A Guide to Bird Watching* by Hickey has many practical suggestions to offer to those who wish to undertake a serious study of bird life. [4] Many volumes of various types will be found on the shelves of most libraries.

Modern trends in the biological sciences have been toward social and economic applications of biology. While bird study is usually thought of as aesthetic and academic in its approach, it, too, has its practical phase. Students interested in conservation have an opportunity to study the relations of birds to insect and rodent pests, predation, weed control, distribution of certain plants, forestry, and the economic and recreational values of game birds. Projects of a practical nature, such as patch planting, winter feeding, establishing feeding and nesting shelters, educating farmers to leave fence rows and field corners for bird cover, can be organized. The relation of birds to the biotic community, and their vital role in maintaining the balance of nature ties up bird life with all other forms of life including man. For general education, and for specialized training, bird study projects have much to offer, perhaps more than any other single branch of natural science.

REFERENCES

1. Dexter, Ralph W. "Field Study—the Backbone of Biology and Conservation Education." *School Science and Mathematics*, 43:509–516, June 1943.
2. Peterson, Roger T. *A Field Guide to Birds.* Houghton Mifflin Co., Boston, 1934. xxi, 167 p.
3. Forbush, Edward H. and May, John B. *Natural History of the Birds of Eastern and Central North America.* Houghton Mifflin Co., Boston, 1939. xxvi, 554 p.
4. Hickey, Joseph J. *A Guide to Bird Watching.* Oxford University Press, 1943. xiv, 262 p.

SCIENCE TALENT SEARCH SCHOLARSHIPS AWARDED

Forty scholarships for the continuance of engineering and scientific education were awarded March 6 at Washington to finalists of the fourth annual Science Talent Search. Top awards, four-year scholarships of $2,400 to a boy and a girl, were granted to Marion Cecile Joswick, 17, of Brooklyn, N. Y., a graduate of Manual Training High School, and Edward Malcolm Kasower, 16, a Brooklyn, N. Y., resident and a senior at Stuyvesant High School in Manhattan. A total of $11,000 in Westinghouse Science Scholarships is awarded each year in the Science Talent Search. The scholarships are provided by the Westinghouse Company as a contribution to the advancement of science in America. The fourth annual Science Talent Search opened last fall when 50,000 high school principals and science teachers were asked to assist in finding the 40 seniors most talented in science in the nation's public, private and denominational schools.

Some 15,000 science-minded seniors entered the Search. Of these, about 3,000 completed the requirements for being considered for the scholarship awards; a stiff, three-hour science aptitude examination; the writing of a 1,000-word essay, "My Scientific Project," and submission by the faculty of complete scholastic and personal records, together with recommendations by teachers and principals.

From these data, 40 of the entrants were selected by the judges as finalists and invited to the Science Talent Institute. During the screening by the judges all entrants were identified only by serial numbers. Names and home towns of the 40 finalists were unknown until they had been selected.

The objectives of the Science Talent Search, as outlined by Watson Davis, Director of Science Service, are (1) To discover and foster the education of boys and girls whose scientific talent indicates potential creative ability and warrants scholarships for its development; (2) To focus the attention of large numbers of scientifically-gifted youths on the need for perfecting scientific and research skill and knowledge so that they can increase their capacity for contributing to the task of winning the war and the peace to follow; and (3) To help make the American public aware of the role of science in the war and in the post-war reconstruction.

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EDUCATIONAL TRENDS

AN ENGINEER AND A BIOLOGIST DISCUSS *EDUCATION FOR ALL AMERICAN YOUTH*

R. WILL BURNETT
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IN the February issue of SCIENCE EDUCATION there appeared a summary and interpretation of a recent publication of the Educational Policies Commission of the National Education Association, entitled *Education for All American Youth.* This document is certain to affect the work of the science teacher, for it proposes radical, if not novel, changes in the curricular organization of the secondary schools of America The fact that these proposals are supported *in toto* by the National Association of Secondary School Principals (who have prepared a summary document, *Planning for American Youth,* which has been given wide distribution among administrators and laymen) suggests that many administrators throughout the country may be disposed to begin modifying curricular organizations in the near future in line with the recommendations proposed.

At the annual conference of the Association of Science Teachers of the Middle States in collabortaion with other teachers' organizations, two eminent scientists discussed this document in regard to its implications for, and possible effects on, science education.

The first speaker was Dr. Harry P. Hammond, Dean of the School of Engineering, Pennsylvania State College, and Chairman of the Committee on Engineering Education after the War, of the Society for the Promotion of Engineering Education. Dean Hammond spoke specifically on the " responsibilities that engineering education fulfills with respect to the profession it serves," and upon this basis expressed the views that he assumes engineers and engineering educators might be expected to hold with respect to the volume *Education for All American Youth.*

NATURE AND RESPONSIBILITIES OF ENGINEERING EDUCATION

Dean Hammond pointed out that the nature of engineering education is largely fixed by conditions external to the program itself. The necessity for graduates of engineering schools having attitudes, knowledge, and skills of such an order as to fit them for first-line technical and administrative positions in American industry and public affairs is set by the requirements of modern civilization and its industrial economy.

> " The general public has come to have confidence in the competence of engineers to discharge their professional duties and there is also increasing respect for their judgment on economic and social problems. The training of engineering students must be such as to justify that confidence. We *cannot* afford to produce a body of ill-trained young engineers, and every part of the educational process must be scrutinized with that in view. Secondary education shares with collegiate engineering education the responsibility of seeing to it that only competent engineers and scientists are produced. Educators may shape the details of their programs so as best to accomplish their purposes, but the major objectives of sound professional disciplines based on adequate knowledge of fundamental laws, technical proficiency in their application, and a broad view of the function which their vocation serves in modern life, is not within their control. This fundamental fact has a definitive bearing on the views that will be held by a professional group with respect to any document dealing with the educational process which is preparatory to service in that profession."

Thus Dean Hammond established his major assumption upon which basis his

analysis proceeded. As the baccalaureate program in engineering generally requires four years beyond the completion of the twelfth grade, it is the task of the engineering colleges to produce in this short time those individuals our society must have who are skilled in the application of the principles of science and techniques of mathematics in the practical arts of engineering. The quality of the product produceable in this time span depends heavily on the nature and quality of the work done in the secondary schools, according to Professor Hammond. For the engineering colleges "can ill afford to go any further downward into the realm of preparatory studies than is inescapably necessary."

What is the typical program of collegiate engineering education?

"Curricula may be considered as comprising two stages: a lower stage of the first two years, devoted chiefly to preparatory work in mathematics, the physical sciences, the verbal and graphical languages of English and drawing, and a few introductory technical subjects; and an upper stage, of the last two years, devoted to the applied mechanics of solids, fluids, heat, and electricity, certain more advanced technical skills, the application of physical principles and mathematical techniques to the solution of practical problems, and, to a limited degree, to engineering specialties and electives."

PREREQUISITES FOR PROFESSIONAL STUDY

Courses in engineering school form definite sequences constituting a stem that may not be broken. "This stem has its roots in the work of the secondary school, where it is imperative that the foundations of knowledge, attitudes, thoroughness, and, broadly speaking, of scholarship must be laid if the student is to be started properly on the long path that leads ultimately to professional competence and thus to useful citizenship." The roots, according to Dr. Hammond, are composed of certain knowledge, skills, and attitudes; more specifically, of effective study habits, quantitative methods of an introductory sort, skill in algebraic operations, a fair conception of plane and spatial relationships, possibly a first course in trigonometry, and "if the students could have had either physics or chemistry, or both, in high school, so much the better." Above everything else, professors of engineering would wish "that their entering students would have learned to study effectively, to work industriously, and not to shirk seemingly difficult or onerous tasks when they encounter them." These roots are reasonable and necessary expectations on the part of the engineering profession.

What, if the limitations of present conditions are ignored, should be set up as an ideal basis for entry to engineering curricula?

"In the secondary school a first-class counseling system would have encouraged those students, and only those, to follow an engineering curriculum who had well above average intelligence and ability to work hard, who had demonstrated capacity to deal quantitatively with physical concepts and scientific principles, and who, especially, were proficient in mathematics and liked to study it. These students, who would normally be found in the top third of graduating classes, would have pursued, under guidance, a solid sequence of courses in mathematics, including elementary, intermediate, and advanced algebra; plane and solid geometry, and trigonometry, which they would complete in not more than three semesters. These students would have had sound introductory work in physics and chemistry, given in regularly organized courses and not picked up in 'common learnings' or incidental to vocational work. These courses would include some solid, quantitative treatment of the subjects, and would include laboratory exercises and problem solving."

Here, then, is the "consummation devoutly to be wished" by instructors of engineering, for it is likely that Dr. Hammond represents a majority viewpoint among this group. It would be presumptuous of one not of the fraternity of engineers to challenge any of these assumptions and the present reviewer is not inclined to question their validity. On the contrary, it appears to him that every suggestion offered has real merit and the secondary schools would do well to provide, on a *selective* and guidance basis, precisely the offerings and experiences Dean Hammond suggests.

PROVISIONS FOR PRE-PROFESSIONAL WORK

If the assumptions made to this point are accepted by the reader, the problem becomes one of assaying *Education for All American Youth* to determine to what extent its recommendations provide for educational experiences of the types recommended above or to what extent they preclude such experiences. A major recommendation of *Education for All American Youth* is the establishment of "common learnings" courses in which provision is made for experiences of presumed value to all youth because they are functionally organized upon certain "imperative needs of youth." The various disciplines, including science, make their contributions to these courses.

Dean Hammond's reaction to the document in question is implied and foreshadowed in his suggestions that students be given sound work in physics and chemistry in regularly organized courses rather than in "common learnings" courses or as incidental to vocational work. He expresses "hearty agreement" with a number of the proposals made. He particularly favors the further adjustment of programs to the interests and capacity of individuals and to the requirements of the vocations they may choose to enter.

Dr. Hammond does, however, express grave concern whether sufficient time is allocated in the eleventh through the fourteenth grades for sound vocational preparation in terminal courses, or for the study of science, mathematics, and similar subjects. He very properly indicates that it is difficult to appraise accurately the recommendations of the report as to preparation for higher education for the reason that the statements of the document are not sufficiently explicit. "Provisions for science and mathematics are lumped together with other studies . . . which makes it difficult to evaluate them individually." However, Dr. Hammond attempts to compare the proposed course provisions with those of the average entrance requirements to accredited engineering colleges. A total of 8 to 9 units (pursued in grades ten through twelve) is commonly required for admission to the stronger eastern engineering colleges; provision is made in the proposals for 6 units in the "Farmville" secondary school and 8 units in the "American City" secondary school for the same grades. "These provisions would be definitely on the low side of normal engineering college requirements."

Dr. Hammond concludes his discussion with the following observations:

> "I confess, in general, to a strong feeling of apprehension and disappointment in studying this document chiefly on two grounds: one that the provisions for preparation in science and engineering are not more explicitly stated and that they seem to be distinctly on the lean side of college preparatory provisions; and the other that so much emphasis is given to general courses such as 'common learnings' to be pursued by all students. . . . It is my chief fear, in reading the document, that the substitution of such broadly inclusive and generalized survey-type material as this for the specific study of individualized courses in science, mathematics, or other subjects requiring hard intellectual effort may result in a smattering of a great deal and a mastery of nothing. In other words, I fear that appreciation has largely taken the place of scholarship.
>
> "I have hoped for the past many years that a statement might emanate from those who gu[illegible] the destinies of secondary education that mo[illegible] adequate provision might be made in this country for sound work preparatory to the sciences, engineering, and the other professions. I fear that a great opportunity has been lost by those who prepared the document under discussion to make adequate provision in the secondary schools for the basic preparation of the future scientists and engineers who are destined to exercise a major share of the responsibilities of shaping the course of the social and economic development of this country in the future."

A BIOLOGIST'S CRITICISM

The second paper read at the conference was by Dr. Oscar Riddle of the Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, New York. Dr. Riddle, like Dr. Hammond, found much to commend in *Education for All American Youth*. Like Dr. Hammond, he chose to devote his attention to those aspects of the report which he believed in need of adverse criticism.

The first—and to the reviewer an eminently valid—point of criticism raised was the issuance of the report and its distribution to school authorities and administrators throughout the country without benefit of mature and constructive criticism of the manuscript at the hands of experts in fields necessarily affected by the document. Yet, any who have worked on committee reports of a professional nature must recall the almost insurmountable problems faced in producing a report. If the Commission's committee had attempted to secure criticism from experts in the many aspects of educational and technical fields and to withhold publication until these were compromised and incorporated the report would not yet have appeared. It would be highly desirable that such policy statements as the one under scrutiny be given to executive committees of representative, responsible organizations before publication and that attention be given to the criticisms forthcoming. Until the science teachers' organizations find representation by affiliation with one central organization or council, such as the National Science Teachers Association of the National Education Association, it is futile to hope that such opportunities will commonly be provided the field of science education.

The second criticism that Dr. Riddle levels at the Commission's report is essentially the same as Dean Hammond's major objection. Because of the importance of this criticism, and because—if valid—the full attention of individual science teachers and that of their organizations should immediately be focused on correcting this potential danger to sound science education, Dr. Riddle's criticism is reported in full.

"Both at 'Farmville' and at 'American City' it is proposed that a course called 'science' should get one-sixth of the fifteen-year-old youth's time in Grade X; but no youth is slated for more. During that same tenth year, this youth gets an exactly equal amount of time for recreation plus physical education, and this latter is repeated in whole or in part throughout a five-year program. Besides, health and mental hygiene get about one-twelfth of the youth's time throughout a five-year period. Examination of the content, or even the full title, of this single year of 'science' leaves no doubt that the thing to be taught is not a science, nor yet is it the sciences—it is *about* science. Its specific name is 'The Scientific View of the World and of Man.' To teach this course a laboratory is apparently not essential. Again, no double periods are provided for this course in so-called science, though double—even triple—periods are carefully provided for the proposed social-studies course called 'community studies.' Concerning this course on 'The Scientific View of the World and of Man' we quote, in part:

> 'Without attempting to describe it in full, we may point out a few of its features. Imaginative association with great scientists is used as one effective way of learning about scientific methods. The history of science is full of adventure and dramatic action, which appeal strongly to young people's interests and arouse their imagination. The lives of some of the great scientists are studied, representing the major scientific fields. . . . Some of the great scientific experiments are also studied, which are within the comprehension of tenth-graders—experiments of recent years as well as of the remote past. Whenever possible those are repeated in the school laboratory. Students see how the experiments and discoveries of scientists have changed our ways of living. . . . Throughout the year, an attempt is made to add to the student's stock of fundamental scientific principles and facts, and to help students see these as related parts of a whole.'

"Now all of us will agree that it is highly desirable that these and many similar things become the possession of every youth; but many experienced teachers of the sciences will insist that these ends cannot be attained in this kind of course pursued to the extent of one-sixth of the youth's time during one year. Many competent teachers will maintain that these aims, together with the grip on reality which only personal laboratory experience can develop, are worth not merely one-sixth of one year's time, but at least one-sixth of four years of the youth's time—from the ninth to twelfth grades, inclusive. Two years of properly organized study of the living world, and another two of the physical world, can be expected to substitute conviction and familiarity for the proposed veneer of classroom conversation about principles and natural laws.

"And, such study can develop still other enduring civic values which must pass unnoted here. Exact and exacting studies do a thing that is tonic and leavening to human beings and to nations. The mental emancipation of majorities, absolutely and always needed among us, conditions the tak-

ing of forward steps in many areas of legislation and of community and family life. It cannot be conceded that this mental emancipation along with a much more definite familiarity with our own bodies, our environment, and the natural world, is a poorer preparation for good citizenship in the Democracy of days ahead than is the proposed 'investigation of current political, economic and social problems' which the plan actually projects even to the nineteenth year of the youth's training. Indeed, in these days of national emergency it should be clearer than ever before that a prime responsibility of the school is partly to equip the citizen with science and the method of science for his life in an age of science."

For the reader who has not yet studied the document in question, it should be pointed out that provision for science instruction is of three types. First, courses in physics, chemistry, and biological science are offered on an elective basis for those whose interests run in this direction and for those interested in college preparatory work. These courses, presumably, would be much as these courses have been in our schools and subject to the same processes of revision that have been going on during the past decade or so. Second, *Education for All American Youth* recommends the establishment of the required course in "science" that Dr. Riddle refers to above. Third, such science experiences may be provided in the "common learnings" sequence of courses, as may be structured and provided for on the grounds that they contribute to one or more of the "imperative needs" of youth. Parenthetically, it is interesting to note that the summary document, *Planning for American Youth*, makes considerably clearer that provision is made for the elective courses in sciences required for certain college preparatory students. It also emphasizes more strongly that science experiences are to be incorporated into the functionally organized "common learnings" courses as fast as teachers can learn to do so.

These remarks do not imply an invalidation of Dr. Riddle's thesis. The danger that this document may, practically speaking, "subordinate," as Dr. Riddle fears, "the teaching of the sciences in our high schools" is tremendously real. But the best possible shield against such an unfortunate development is clearly not negative defense of the *status quo* in science education but a full-bodied and positive attempt on the part of organized science educators to structure out a scope and sequence of science content and experiences of demonstrable significance to young people and society. Such, in essence, may be Dr. Riddle's recommendation, if we read his paper correctly.

The third major criticism that Dr. Riddle presents seems highly significant. It is in regard to the proposed program in health. The report provides for one hour a day throughout the secondary school to be set aside for health instruction and physical education. Dr. Riddle's criticism is this:

"There should be clear recognition of the importance of interrelationship, and of sequence of instruction, in the two subjects—biology and health. This is ignored by the Commission's plan, just as it is most unfortunately ignored by the new law of the State of New York requiring the teaching of health in its schools. Let me make it clear that I am among those who think there should be sound instruction in health and hygiene in the high schools. . . . Let us indeed make a reasonable effort to teach the foundations of health; and in the high school let us arrange to teach it in connection with, or following, courses in human physiology or in biology."

Dr. Riddle's point, of course, is that sound health practices are a function of understandings of the mechanics and chemistry of the human body and the disruptions of those functionings through invasion of disease or otherwise. Health, as it has so commonly been taught, has been a series of "chalk talks" or lectures of moralizing tone *sans* the understandings of the interrelationships of the bodily parts and functions without which such instruction can, at best, be only verbalistic and non-functional. The Commission's report will appear to many to be vulnerable on this score.

The final major criticism presented in

Dr. Riddle's paper may well represent an exaggerated fear. Dr. Riddle states:

> "There is one reason, almost never mentioned, why in the days ahead biology *must* be taught widely and well in our Democracy. It is this. At present only biologists may be expected to teach the fact, and the foundations of the fact, that human beings are genetically and biologically *un*equal. . . . As a biologist, more or less familiar with human and animal genetics, I am aware of the gradations of abilities, possibilities, and susceptibilities among the members of all communities—even in the same families—that depend upon the chance union of genes. But I am even more impressed with the circumstance that it may be highly dangerous for present and future youth of this country to fail to learn, assimilate and accept this reality. Data published two years ago by a committee of which I was chairman indicated that about 6 of 7 of the responding biology teachers taught this principle. Those teachers indicated that in their schools this principle was very rarely taught in social-studies classes."

The importance of this understanding is in no way to be decried. Biology teachers can make an unique contribution toward this understanding. It does appear presumptious and naive for biology teachers to state that the genetic inequality of individuals is not taught by social-studies teachers. The very report being considered was entitled *Education for All American Youth* precisely on the grounds that traditional secondary education had signally failed to provide for the different needs and interests of young people. Explicitly stated as basic to the recommendations of the report is the fact that individuals differ in sex, race, and nationality. They differ in home and socio-economic background and status. They differ in emotional and physical health. They differ in intelligence and aptitudes. It is true that this suggests differences in individuals due to varying cultural as well as biological inheritances. It is true that the biologist can contribute heavily to basic understandings of differences and the genetic basis for such differences. It does appear, as well, that other teachers may have contributions to make on this important truth. Surely the biologist should be given full opportunity to teach the genetic facts.

> "It must be clear and certain that the youth for whom [the Commission plans] must live in an age shaped and being reshaped by science, and that these youth cannot escape repeated and important decisions on complex social adjustments imposed by scientific discovery."

Thus, in concluding, does Dr. Riddle request a review of the Commission's document in light of the contributions that science education may make to youth and society. The acceptance of this report generally and in local communities, the direction curriculum modifications take, and the place that science education has in the future education of youth depend not so much on this report as on the basic soundness with which science educators demonstrate what science experiences can contribute to youth and to these "repeated and important decisions" that must be made. The science education in the Farmvilles and American Cities of the future will be that which science educators can demonstrate to be of greater personal-social value than competing offerings.

RESEARCH DEPARTMENT

IMPROVING RESEARCH THROUGH A PRE-ABSTRACTING SERVICE

SHAILER PETERSON
University of Chicago

THE term preabstracting, as it is used in this article, refers to the publication of research plans before the research itself has been fully undertaken. It is the purpose of this writer to demonstrate how this medium of reporting could facilitate research and improve its caliber.

Most of those who follow the literature in an effort to keep abreast of new research that is reported are impressed sooner or later by the fact that many studies could have been improved if each had been conducted cooperatively with some other study.

Everyone is indebted to those men who during the past years have kept their colleagues informed on current dissertation titles. These lists, however, have not included post-doctoral research studies, regional research titles, college-wide research topics, and the like. Then too, no title can suggest exactly what is being undertaken, its scope and method of attack. Even long titles of the summary type fail to enlighten the reader very much. More than one hooded faculty member has chuckled on commencement day over the inadequate but spicy sounding titles of dissertations completed in departments other than his own. Everyone will admit that titles themselves are hardly sufficient to encourage correspondence between research workers.

Nearly every research worker is conducting one major piece of research and has several other topics upon which he has done some preliminary work. Visualize the potential amount of assistance that is therefore available, for it is very likely that a dozen able persons throughout the nation have given serious thought and consideration to the same project. No one with the will and ability to conduct research has a mind so barren of new ideas that he jealously would want to hide his own from view or want to keep them from shedding some degree of illumination in another office, in another department, or on another campus. It is safer to assume that most of them would wish that the next projects to be undertaken on another campus be in some way related to the pet ideas in the back of their own minds.

Let us imagine a certain Mr. Smith of Oshkoshiliza University who is starting an evaluation study on some phases of methodology. Let us assume that Mr. Smith has given considerable attention to his problem, is familiar with the published literature, and that he has some definite ideas of what he wants to investigate and how he believes it can be done. He also realizes that there are certain evaluation tools or tests which he may have to prepare for there are apparently no suitable ones available. If Mr. Smith's problem and his planned method of approach were reported in a preabstracting section of a professional journal, it would be possible for his project to be brought to the attention of other research men. It is highly probable that many men would have suggestions to offer and be able to direct Mr. Smith to sources which would otherwise not be generally available. Mr. Smith might find coopertaing schools and classes in other cities. Other graduate students throughout the nation who would

read of Mr. Smith's anticipated work, might be toying with some new measuring device which they would offer to Mr. Smith in exchange for a footnote of credit. As a result of the efforts of the graduate students and of leaders in educational research throughout the nation, Smith's research would be materially improved and made more meaningful.

It seems obvious that the initiation of such a scheme of publicizing research would result in correspondence and cooperation between a great many research workers. At the University of Chicago meeting of the National Association for Research in Science Teaching the members of the group all seemed to agree that a preabstracting service would be a valuable contribution to research in science education.

It would be the function of the conductor of this service to correspond with leaders everywhere who would in turn keep him informed on research being conducted on their campus or in their region. A certain number of canvassing letters could be sent out but this should not be depended upon as a source of all of these data. Letters from some research workers might outline their proposed researches completely enough that proper informative digests could be composed. However it would be expected that in most instances it would be necessary or at least desirable to supplement the first information by further correspondence so that the digest could include sufficient information about

(1) Title of project
(2) General objectives
(3) Specific aims
(4) Design of experiment
    (a) Description of groups or population to be used and method of selection
    (b) Statistical techniques to be employed such as methods of equating groups
    (c) Tools to be employed such as measuring instruments and available data
(5) Proposed scope and length of experiment; the nature of progress reports which will probably be released before final results are complete.
(6) Location of worker and location of experimental and control groups
(7) Names of worker's colleagues and/or major adviser
(8) Source of funds for supported project

A DETERMINATION OF THE PRINCIPLES OF THE BIOLOGICAL SCIENCES OF IMPORTANCE FOR GENERAL EDUCATION

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IF THE results of surveys and research studies concerned with the curricular offerings in science furnish valid indices of the trends in this area then it is evident that eventually our science courses on the elementary, secondary, and junior-college levels of the public schools will be, for the most part, general courses. These courses will be an integral part of the total curriculum designed to furnish *general* education rather than propadeutic or preparatory education. Thus the teachers of science, in planning for general education, are faced with the obligation of determining what are the important principles of science of which an understanding is necessary for the solu-

tion of the problematic situations which arise in everyday life. The report that follows is based upon a recent attempt at such a determination.

The purpose of the investigation was to determine the principles of the biological sciences which are of importance for general education.

Several important terms which occur repeatedly throughout the study are defined as follows:

A *principle* is defined in terms of two criteria:

For a statement to be a principle:
(1) It must be a comprehensive generalization which resumes the widest possible range of facts within the domain of facts with which it is directly concerned. The facts resumed in the generalization must denote
  (a) objects and/or events and the relations between them, and
  (b) properties.
(2) It must be scientifically true. To satisfy this criterion it must be
  (a) verifiable; i.e., it must be stated so that it suggests, either directly or indirectly, a definite operation of observation or experiment whereby its truth value can be tested or verified.
  (b) consistent with the body of accepted scientific knowledge, and except for a few limiting or singular exceptions, with all the data relevant to it.

Biological sciences are those sciences which are directly concerned with living organisms and with the life processes and relationships of these organisms with the organic and inorganic elements of their environment. These sciences, according to Shull, are limited to "the five sciences, morphology, physiology, taxonomy, evolution, and genetics, which are the main fundamental divisions of pure biology." [1]

General education is that education which purposes to meet the needs of individuals in the basic aspects of living, in such ways as to promote the fullest possible realization of personal potentialities and the most effective participation in a democratic society. [2] It designates those educational activities which are planned to meet the needs of all pupils enrolled in elementary and secondary schools (grades 1–14, inclusive) without regard to their probable future vocational or professional interests.

The investigation was divided into two parts: the inductive phase, and the deductive phase which were attacked in the order named. The present report is concerned with the inductive phase of the study.

The purpose of the inductive phase of the study was to secure a tentative list of the important principles of the biological sciences. This major problem was broken down into three sub-problems each of which was attacked separately.

GENERALIZATIONS FOUND IN BOOKS ON BIOLOGY

Sub-Problem I: To determine the important generalizations of the biological sciences which occur (1) in textbooks prepared for survey courses in the natural sciences at the junior-college level of the public schools, (2) in textbooks prepared for use in courses in biology at the secondary level, and (3) in a survey series of the biological sciences prepared for the general reader.

Techniques Employed

A committee of three persons, all engaged in the teaching of science and the training of teachers in the School of Education at the University of Michigan, met with the investigator to examine the available books, in the categories mentioned, and to set up criteria by which to determine those best suited for analysis in this study. The criteria set up for the determination of suitability were:

(1) In the preface the authors must give definite evidence of agreement with the objectives of general education.
(2) In the textual materials there must be direct statements of principles, or major generalizations, or of statements which contain unmistakable implications of principles, which conform to the criteria set up in this study for the determination of a principle.

As a result of this examination the committee agreed unanimously that three

junior-college textbooks, three high-school biology textbooks, and a four-volume survey series of the biological sciences satisfied the criteria and thus were suitable for analysis.

A series of consultations with the members of this committee resulted in the setting up of the following criteria for the selection of biological generalizations from the textual materials of these sources.

A statement in the source is to be regarded as indicating an attempt on the part of the author to teach, or to develop in the reader an understanding of, a generalization:

(1) If it states a generalization of the biological sciences.
(2) If, though it states no biological generalization, it can be restated so that it does, or if it can be combined justifiably with an accompanying statement from the source into an acceptable statement of a generalization.
(3) If it relates unmistakably to a generalization by furnishing a clear illustration of it; if it uses terms which are unquestionably related to a generalization and which require an understanding of the generalization for an understanding of the term; or if it describes relationships, processes, or interactions which are unmistakably related to a generalization.

The materials appearing in each of the sources were read and analyzed by the investigator for statements of biological generalizations which satisfied the criteria. As the generalizations were found, each statement was written on a card exactly as it appeared in the source with a notation as to the source from which it was secured. The cards were then filed under appropriate topic-headings according to a system of classification arbitrarily set up by the investigator, but subsequently validated as being suitable by a committee of five persons to whom it was submitted.

Findings

A total of 705 different generalizations of the biological sciences was secured by the application of these techniques to the materials in the sources. These generalizations were distributed as follows: 234 from the junior-college textbooks, 204 from the high-school textbooks, and 267 from the survey series prepared for the general reader.

GENERALIZATIONS IN LISTS OF PRINCIPLES

Sub-Problem II: To determine the generalizations of the biological sciences that appear in the lists of scientific principles in published, and readily available unpublished, reports of research studies.

Techniques Employed

The lists of scientific principles appearing in the reports of five research studies [3, 4, 5, 6, 7] were used as a source of biological generalizations. As a basis for selecting the studies to be used as sources the following criteria were set up by the investigator and accepted as suitable by the members of the committee which formulated the criteria used in Sub-Problem I.

In order to be considered a suitable source of scientific principles

(1) The investigation must have been undertaken at a well-known university of the United States as a research study which satisfied the requirements of the institution for the securing of an advanced degree.
(2) It must have been undertaken for the stated purpose of selecting generalizations or principles of science.
(3) The available report must contain (a) a detailed account of the techniques and criteria used for selecting the generalizations or principles, and (b) a list of generalizations or principles which were deemed defensible, by the person selecting them, in terms of the techniques and criteria employed.

Each list was read and each statement of a generalization or a principle, which was classified as biological in the list, or which was considered by the investigator to be biological in nature, was written on a card. Each of the cards was then filed

under an appropriate topic-heading along with the cards bearing statements of generalizations which had been secured from the sources used in the preceding problem.

Findings

A total of 126 generalizations of the biological sciences was secured from the lists. These generalizations were distributed as follows: 64 in Robertson's list, 29 in Downing's list, 5 in Pruitt's list, and 79 in Olds' list.

WHAT GENERALIZATIONS ARE MOST IMPORTANT?

Sub-Problem III: To determine what are the important major generalizations, or principles, of the biological sciences.

Techniques Employed

The statements of generalizations on the cards in the file were examined, one by one, by the investigator and a cooperating committee member, to determine whether there was any duplication of statements and whether the statements could be improved. Then those statements which were considered to be identical or nearly alike were compared, and the one which was the most acceptable statement of the generalization involved was retained in the file. If the wording of a statement was unacceptable in terms of the criteria set up for determining whether a statement was or was not a principle, it was reworded and the card retained in the file; if the statement could not be reworded acceptably at this time, the notation "Reword" was written on the card which was retained in the file for later treatment.

A composite list was then made of all the statements of generalizations, under the same topic headings and in the same order as they appeared in the file.

The composite list was submitted to a jury of three persons who evaluated each generalization in terms of these criteria: (1) Is the statement a generalization of the *biological sciences?* (2) Is the statement a *principle?*

Those statements which qualified under both criteria were designated as being major principles. Those statements which qualified under Criterion 1, but which were considered to be not comprehensive enough in scope to qualify under Criterion 2, were designated as being minor principles. These statements were formulated into a list of "minor" principles for use in the deductive phase of the study.

Each statement which needed rewording in order to be a generalization of the biological sciences was reworded, if possible, so that it satisfied one or both of the criteria. If, after rewording, it satisfied both, it was designated as a "major" principle; if it satisfied only the first criterion, it was entered as a minor principle on the list.

All those generalizations which were judged to be major generalizations, or principles, were combined into one list. This list of major principles was submitted to a member of the Department of Zoology and a member of the Department of Botany at the University of Michigan who were requested to improve and refine the statements of the principles wherever necessary and possible. Each specialist was asked to judge whether each statement was "true without exceptions, within limitations specifically stated." Any statement which was not scientifically true and which could not be reworded so as to be a true statement which satisfied the criteria set up, was dropped from the list.

Those principles which were retained in the list by the subject-matter specialists were organized into a "master" list of the important principles of the biological sciences. These principles were ranked in descending order on the basis of the total frequency of appearance of each principle in all of the sources analyzed in Sub-Problems I and II.

Findings

The "master" list of the major biological principles contained 300 different principles. The "minor" list of principles, which was not evaluated by the subject-matter specialists, contained 236 different minor principles.

The principles in the "major" and "minor" lists were used in the evaluations which were employed in the later, deductive phase of this study.

The twenty major principles receiving the highest ranks in this phase of the investigation follow in decreasing order of their importance:

(1) The cell is the unit of structure and function in all organisms.

(2) The protoplasm of a cell carries on continuously all the general processes of any living body; the processes concerned in the growth and repair, or upbuilding of protoplasm (anabolism), and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

(3) All life comes from preceding life.

(4) Living things alter their types: present species have not always existed, but have originated by descent from others which in turn were derived from still earlier ones, and so down to the first living forms.

(5) Since the genes of the two parents combine at random in the germ cells and since the germ cells meet at random in fertilization, the individuals of any generation occur in certain predictable ratios.

(6) Throughout the life of every organism there is a building up and a tearing down of protoplasm with constant transformations of energy.

(7) The fuel requirements of every living thing are: fuels capable of yielding, when oxidized, the supply of energy without which life cannot continue; materials for growth and for replacement of the slight wearing away of the living tissue involved in any activity; and minerals, the necessary constituents of cell structures, of cell products, and of the bathing fluid of cells.

(8) Digestion in plants and animals is carried on by enzymes, or organic catalysts, which are made by the organisms themselves and which take part in and speed up the chemical reactions but do not undergo any permanent chemical change themselves.

(9) Every individual organism is composed of distinct hereditary characters which are transmitted by distinct hereditary factors (genes). In a hybrid the different parental genes are combined. When the sex cells of the hybrid are formed the two parental genes separate again, remaining quite unchanged and pure, each sex cell containing only one of the two genes of one pair.

(10) All individuals of the first generation of hybrids, the F_1 generation, are uniform in appearance in alternative inheritance; only one of the two parental characteristics, the stronger or the dominant one, is shown. In intermediate inheritance a mixture of the parental characteristics is shown.

(11) Energy can be transformed into mass and mass into energy, but the sum total, mass plus energy, remains constant.

(12) Energy and matter are not created or destroyed in the reactions associated with the life processes, but are passed on from organism to organism in endless succession.

(13) In the presence of sunlight the chloroplasts of chlorophyll-bearing plants convert carbon dioxide and water into intermediate substances, and these into sugar, and that into starch, and liberate oxygen; thus directly or indirectly producing practically all the food in the world.

(14) All the higher forms of terrestrial life are dependent either directly or indirectly on the soil bacteria for their nitrogen supply.

(15) All living organisms (except viruses and bacteriophage) carry on the common life processes; reproduction, growth, nutrition, excretion, respiration, and irritability.

(16) Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of the transportation (circulatory) system.

(17) Reproduction is a fundamental biological process that provides for the continuance of life on the earth by providing new individuals.

(18) The hereditary characteristics possessed by any organism depend wholly upon the genes that were transmitted to it in the reproductive cells received from its parents.

(19) Each kind of living thing has its characteristic chromosome complement, and the constancy of that complement is preserved at each cell division. Different species show the utmost diversity in number, size, and form of chromosomes.

(20) New kinds of living things have arisen through mutation.

CHECK ON THE RELIABILITY OF THE ANALYSIS OF THE MATERIALS IN THE SOURCES

On completion of the analyses described it was evident that there were two possible sources of variability inherent in the method of analysis employed. This variability could result from the subjective factor of human judgment in (1) the selection of the statements of generalizations from the sources, and (2) in the application of the criteria to the selected statements.

Techniques

In order to test the reliability of the investigator's judgment in determining which statements were generalizations, the materials in one of the junior-college textbooks were analyzed again, and exactly the same techniques and criteria as had been employed in the original analysis were again used. This second analysis was made ten months after the original analysis, and after all the remaining units of the study had been completed, and it followed all the extensive analyses which were made in the study. Hence, it was assumed that after this length of time the practice effects of the original analysis could not materially influence the results of the second analysis.

The quotient (ratio) obtained by dividing the number of major generalizations and minor generalizations common to the two different analyses, by the total number of different generalizations resulting from both the original analysis and the check analysis was assumed to be an index of the reliability of the investigator's judgment in determining which statements in the source were generalizations.

Findings

The number of generalizations common to the two different analyses was 92 and the total number secured from the original and the check analysis was 94. The ratio was .979. If it is assumed that the materials selected for re-analysis represent an adequate sampling of the basic sources used, then this mean ratio of .979 indicates that the original analysis of all the sources was reliable, and that the lists of major and minor principles secured in these analyses contain most of the generalizations which appeared in the sources.

REFERENCES

1. Shull, Franklin. *Principles of Animal Biology.* New York: McGraw-Hill Book Company, Inc., 1941. 21 p.
2. Progressive Education Association, Commission on Secondary School Curriculum. *Science in General Education.* New York: D. Appleton-Century Company, 1938. P. 23.
3. National Society for Study of Education, *Thirty-First Yearbook,* Part 1, Chap. XIV, Public School Publishing Company, Bloomington, Illinois, 1932. Pp. 224–226.
4. Robertson, Martin L. *A Basis for the Selection of Course Content in Elementary Science.* Unpublished doctoral dissertation, University of Michigan, 1934.
5. Pruitt, Clarence M. *An Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry.* Doctoral dissertation, Teachers College, Columbia University, 1935. Distributed by *Science Education.*
6. Arnold, Herbert S. *The Selection, Organization, and Evaluation of Localities Available for Unspecialized Field Work in Earth Science in the New York City Region.* Doctoral dissertation, Teachers College, Columbia University, 1936.
7. Olds, Raymond C. *The Principles of Biology for Secondary Science Instruction.* Unpublished master's thesis, Colorado State College of Education, Greeley, Colorado, 1936.

RECENT BOOKS AND ARTICLES

BOOK REVIEWS

BAKER, JOHN R. *The Scientific Life.* New York: The Macmillan Company, 1943. 154 p. $2.50.

A prominent British biologist gives here his view that "the spirit of free enquiry is threatened today." He frankly fears "planning" since he concludes that it threatens freedom in science, and that when research is planned not only do scientists lose freedom but all scientific effort would be required to have practical outcomes.

Even though one disagrees with the author's thesis, the book is well worth careful study. The analysis of the meaning of science, the nature of research, "the uses of science," and "science in the age of technology" make stimulating reading. As Professor Baker points out, so long as large sections of the population are influenced in their everyday lives by astrology and the like, science teachers still have much unfinished business.

In the Preface he expresses the hope that some thoughtful boy or girl may read this small volume and "decide to live the scientific life." Both parent and science teacher may contribute to such result, especially by pondering the chapter, "People as Scientists."

—M.E.O.

BEEBE, WILLIAM. *The Book of Naturalists.* New York: Alfred A. Knopf, Inc., 1944. 499 p. $3.50.

Its subtitle is "An Anthology of the Best Natural History" and the jacket adds, "The greatest writings from the ancients to the moderns."

In schools where the curriculum has been organized around problems of living and to meet the needs of pupils, teachers almost invariably report marked increase in reading both by students and teachers. This is the type of book which may well be included in any school library.

Beginning with reproductions of cave paintings from the Stone Age, and proceeding with selections from Aristotle, whom the editor calls "the founder of natural history and the greatest naturalist of all time," these selections, arranged by date of publication, extend through the centuries and include several contemporaries. Altogether 45 naturalists are represented. In the Preface, Dr. Beebe lists 65 others, "any or all of whom might with propriety [also] have been included."

The volume is arranged in two parts: the first, from ancient times and "the painfully slow development of natural history through the Middle Ages" (which Beebe calls "the extensive drought in human mental history") beyond the Renaissance to Audubon and Thoreau; Part II beginning with Darwin, "the second landmark of greatness," to the present.

"In all the literature of science, no better writing exists than in the field of natural history." There were two criteria for selection: "adequate in scientific soundness and literary quality" (p. ix).

The classics, such as Huxley's "On a Piece of Chalk" and Muir's "The Water Ouzel" are here. Reading them all in this sequence is a fascinating experience. Young minds can get from them the story of human progress from the "curious mixture of fact and myth of Pliny" to the painstaking observations of Reaumur and many others. One clear example is that of the eel, which Aristotle states, "is neither male nor female and can engender nothing," but whose incredible life-history is so well told in the last selection in this volume.

—M.E.O.

HUXLEY, JULIAN. *On Living in a Revolution.* New York: Harper & Bros., 1944. 242 p. $2.75.

This thought-provoking book consists of essays by the well-known British biologist and thinker on a wide variety of topics, held together by the thread of the place of science as the real "wave of the future," which can guide the oncoming economic and social forces to work for democracy rather than for totalitarianism.

The word "revolution" is sacred to us when applied to that which Washington led, but it is obnoxious to some people in any other connection. The principal issue of our times, as stated in a recent editorial is: "Shall we have more for the many by democratic means, or more for the few by privileged means?" Today's revolution is from the latter to the former.

Science teachers are in a peculiar position of leadership which makes an understanding of the nature of the world in which we live of primary importance and urgency. The title essay in this volume is urgent reading for us in this connection.

Other essays in this collection which are of cogent significance include: War as a Biological Phenomenon; Animal Pests in Wartime; "Race" in Europe (alone worth the price of the book); Philosophy in a World at War; Tennessee Revisited: The Technique of Democratic Planning—one can scarcely omit any of the table of contents.

The concluding essay, Education as a Social Function, is worth recommending to all teachers and administrators, not just to scientists.

—M.E.O.

MATHER, KIRTLEY F. *Enough and to Spare.* New York: Harper & Bros., 1944. 186 p. $2.00.

"Mother Earth Can Nourish Every Man in Freedom" is printed as subtitle to this slender volume by Harvard's geology professor, whose lectures always draw capacity enrollment.

The revolutionary concept expressed by this title is new to many people; it is the history of ideas that when new they are vigorously resisted but gain acceptance when clearly presented to the public in the light of supporting facts. Professor Mather here marshals the evidence under such rubrics as: Nature's Stored Capital; Population Trends, The Ability of Science to Meet Future Demands; The Age of Interdependence; Oil for the Lamps of Democracy; Planning for Freedom. Appendix A, Notes on Natural Resources and their Utilization, and Appendix B, Statistical Data, together with a working Bibliography for each chapter and a useful Index, round out the book.

In Chapter 5, the author poses the question, "How can two or three billion human beings be satisfactorily organized for the wise use and equitable distribution of resources that are abundant enough for all, but [which] are unevenly scattered over the face of the earth?" The remainder of the first paragraph merits quotation: "This is the critical question for the twentieth century, a question far easier to ask than to answer. It cannot be evaded, even by the citizens of the United States. Peace and security during the post-war years, for us and for all the peoples of the earth, depend upon finding and applying the correct answer. We move forward, therefore, from a survey of facts to an examination of their implications for the life of man." To answer the above question, two antagonistic alternatives are at present locked in a death struggle. They are the principle of regimentation and coercion versus that of democracy and cooperation. The former is "an attempt to hold back the advancing tides of human evolution."

Other science teachers may well use Mather's analysis to aid them in finding and disseminating the social import of science.

—M.E.O.

O'NEILL, JOHN J. *Prodigal Genius: The Life of Nikola Tesla.* New York: Ives Washburn, Inc., 1944. 326 p. $3.75.

This is the dramatic story of a scientific "superman": Nikola Tesla. It is commonly agreed that Tesla was the possessor of one of the most amazing scientific minds of the present age. He literally electrified the world. Father of the modern system of power transmission, discoverer of the rotating magnetic field and of the principle of alternating current, he put Niagara Falls in harness; in 1898, he operated a boat by remote control; produced the first bolts of man-made lightning; and demonstrated the wireless transmission of power and light. Yet as spectacular as all his inventions seem, his truly monumental discoveries were in the basic principles of electricity.

Born in Yugoslavia, his accomplishments were made in his adopted country, America. His brilliant, eccentric personality gives to Tesla's life story an atmosphere of strange adventure. He made his first million before he was forty, yet gave up the royalties on his most profitable inventions as a gesture of friendship, and died almost in poverty. He refused to accept the Nobel Prize. Tesla was one of those geniuses whose contributions to human comfort and happiness can hardly be overestimated.

This is an excellent book for the high school boy interested in science as well as for the science teacher who teaches him.

—C.M.P.

MEMBERS OF THE FACULTIES OF THE UNIVERSITY OF CALIFORNIA. *Science in the University.* Berkeley: University of California Press, 1944. 332 p. $3.75.

This volume of scientific papers was published in commemoration of the seventy-fifth anniversary of the founding of the University of California. The papers are intended for a less specialized audience than experts. For the lay reader they offer an up-to-date series of treatises on various aspects of science.

The reviewer especially liked the following articles (other articles would likely have as great appeal to other readers): "Driving Back the Dark," "Cosmic Rays," "The Facts of the Organic Chemist," "The California Current," "Evolution of a Sierran Landscape," "Longevity in Organisms," "Trees and History," "The Contributions of Psychology" and "Life, Morals, and Huxley's Evolution and Ethics." Other articles include: "Molecular Forces and Solubility," "The Chemistry of the Amino Acids and Proteins," "What Makes the Barometric Pressure Rise and Fall?" "Subsidence and Elevation in the Los Angeles Region," "A Modern Concept of Living Material," "On Some Facts Pertinent to the Theory of the Gene," "The Study of the Sea and Its Relation to Man," "Ornithology of the Looking Glass," "General Aspects of the Study of Plant Nutrition," and "Physiology as an Independent Science."

—C.M.P.

WEIGERT, HANS W., AND STEFANSSON, VILHJALMUR, Ed. *Compass of the World: A Symposium on Political Geography.* New York: The Macmillan Company, 1944. 466 p. $3.50.

The American public has become increasingly aware that the shrinking of the world brought about by the rapid advance of industry and technology necessitates a new vision. That vision requires, in particular, certain vital applications of today's geography to the politics and strategy of the United States as a leading partner in rebuilding the world.

History is geography set in motion. Never

before has movement been so rapid and turbulent as today.

This book is intended to correct some of the basic misconceptions of political geography which threaten to confuse the minds and the plans of statesmen, soldiers, and the general public alike.

The opening chapter of the book deals with the ideological aspects of geography in international politics; they have in common the warning against the acceptance of the power-political scheme which has found expression in the pseudo-science of geopolitics.

The second paper bears the title "New Direction and Skyway." The articles, "World View and Strategy," and "The Myth of the Continents," are written with clarity and interesting appeal.

The significance of the "Heartland" (the black earth belt and adjoining area in Eurasia) in world affairs is the underlying idea which links the articles in a chapter entitled "Reflections on the Heartland." Discussions of the balance of power, manpower and its relation to war and peace, and the northern hemisphere and its significance to future development of air transportation, complete this symposium so ably edited by Weigert and Stefansson. —C.M.P.

DREW, CHARLES E. *How to Pass Radio License Examinations.* New York: John Wiley & Sons, Inc., 1944. 320 p. $3.00.

Some 1300 questions of the Federal Communications Commission Study Guide are discussed and explained. These questions cover radio laws, basic theory and practice, radio telephone, advanced radiotelephone, radiotelegraph, and advanced radiotelegraph. This is an excellent reference for teachers and students interested in radio or in taking radio license examinations. —C.M.P.

BROUWER, DIRK, KEATOR, FREDERIC AND MCMILLEN, D. A. *Spherographical Navigation.* New York: The Macmillan Company, 1944. 200 p. $5.00.

The spherographical system of celestial navigation is described in this book. It gives directly and visually the latitude and longitude of the observer, by the simple plotting of observed altitudes on the sphere. It is claimed that "aside from the simplification of the solution provided by the method, and the speed with which a solution can be obtained a distinct advantage lies in the ease with which it can be learned. The beginner without previous training in celestial navigation can learn the methods in approximately three weeks time; an accomplished navigator can acquaint himself with the operation of the instruments and the methods of construction within a few hours."

—C.M.P.

GRIMES, DAVID. *Meet the Electron.* New York: Pitman Publishing Company, 1944. 120 p. $2.00.

This is an excellent book for the high-school pupil interested in physical science. The treatment is definitely non-technical, yet it is authoritative. The author is one of the outstanding men in his field. His experiences date back to World War I when he did government research on radio navigation. Later he was a research engineer with the American Telephone and Telegraph Company and still later with RCA and then with Philco.

Electronics has evolved over a period of twenty years, and the development has been very rapid since the outbreak of World War II. Wartime findings in this field will have many practical and startling peacetime applications. —C.M.P.

JAQUES, FLORENCE PAGE. *Snowshoe Country.* Minneapolis: The University of Minnesota Press, 1944. 111 p. $3.00.

Here is a story, written in diary form, of the experiences of the author and her husband during a winter in the border country of Minnesota and Canada. Her account of the approach of winter and of the excitement and peace of isolation in the wilderness is particularly well done.

The author's husband, Francis Lee Jaques, has furnished about fifty of his characteristic black-and-white drawings which are especially effective—snow and pine in striking contrast. An outstanding nature artist, he has long been acquainted with the Arrowhead Country; and like the narrative, his illustrations capture the spirit of winter in the north.

The Jaques are already well known for their earlier books, *Canoe Country* and *The Geese Fly High.* —ROY V. MANEVAL.

ABSTRACTS

CURTIS, FRANCIS D. "The Mathematical Vocabulary Used in Secondary-School Textbooks of Science." *Journal of Educational Research* 38: 124–131. October, 1944.

The purpose of this investigation was to determine which "difficult" words found in textbooks of high-school science are mathematical terms. Six criteria used by the investigator (Hannon) to select "mathematical terms" are included in the article. Hannon's study analyzed and synthesized data from thirty-three master's theses, each of which included a word-by-word analysis of the entire content of one widely used textbook of high-school science, all of which together present a study of more than five million running words contained in nine textbooks of physics, eight of chemistry, ten of general science and six of biology.

A term was defined as "difficult" if it does not occur in the first six thousand words of Thorndike's twenty-thousand word list.

The distribution of mathematical terms in the high-school science textbooks were as follows:

Textbook	Average Number of Different Difficult Words per Book	Average Number of Different Difficult Mathematical Terms per Book	Average Percentage of Different Difficult Words that are Mathematical Terms
Physics	1407	159	11.3
Chemistry	1901	90	4.7
General Science	2109	103	4.9
Biology	3019	81	2.6

—C.M.P.

KITTLE, MARIAN A. "Trends in the Use of Statistical Tools in Educational Research Articles." *Journal of Educational Research* 38: 34–46. September, 1944.

During the last two decades a knowledge of statistical tools has become more and more necessary for a comprehensive reading of publications and for working in the field of educational research. The author reports in this article the results of her research as to what if any, changes in the use of statistical tools have occurred during the period 1920–1940. Articles in the *Journal of Educational Research* were used as a basis of the study.

Findings included the following: (1) No new tools of any noticeable popularity have appeared since the period 1926–1930. (2) Neither has any of the frequently used tools of twenty years ago decreased in popularity to any noticeable degree. On the whole frequencies have remained fairly constant. (3) Authors are using twice as many tools per article as formerly. (4) Writers are breaking away from the old idea that everything must be shown in both tabular and graphic form. (5) In the case of central tendency, the mean has increased in frequency, the median decreased. (6) A larger degree of standardization of terms and symbols would make for ease of reading and understanding research reports. —C.M.P.

POLEY, IRVIN C. "What Every Young Teacher Ought to Know." *The Clearing House* 19:304–309. January, 1945.

This article does not deal with methods of teaching, but with tricks of the trade—"the little things that aren't in the books." While particularly intended for young teachers, teachers of experience need to self-check themselves on the following: (1) Don't expect the impossible of yourself. (2) Expect the possible. (3) Keep as well as possible. (4) Your mental health is as important as your physical. (5) Be a person in your own right. (6) Try to enjoy something in each pupil. (7) Boys and girls really are different. (8) Trust your pupils, but don't tempt them. (9) Include routine as well as variety in your plans. (10) If you must punish, give yourself time to do it wisely. (11) Don't try to use influence until you have it. (12) If you need help that the principal can give, tell him so. (13) If you can't be happy under his leadership, get out. (14) Keep him informed, but don't be long-winded about it. (15) Get the help that older teachers can give you. (16) Think ahead when any of your projects involve other people, especially janitors. (17) Try to find something to like in each of your colleagues. —C.M.P.

WRIGHTSTONE, J. WAYNE. "Evaluation of the Experiment with the Activity Program in the New York City Elementary Schools." *Journal of Educational Research* 38: 252–257. December, 1944.

This article summarizes the results of a study of selected New York City elementary schools, half of which were conducted on an activity basis and half of which were of the non-activity type. Two appraisal programs were used: One was an appraisal of effects upon school practices and the second, an appraisal of the effects upon children.

Results of the evaluation program showed that the activity program was as effective as the longer established program in developing children's mastery of fundamental knowledges and skills, that it was more effective in developing children's attitudes, interests, social behavior, ability to think and ability to work on their own initiative.

—C.M.P.

SCHLESSER, GEORGE E., AND YOUNG, E. W. "Study and Work Habits." *The School Review* 53: 85–89. February, 1945.

This is the resumé of a study of 498 male freshmen entering Colgate University in the years 1941 and 1942. The purpose was to differentiate between study traits that are functions of intelligence and those that make for achievement irrespective of intelligence.

Results indicate that, if one wishes to improve a student's work, it is less important to coach him in techniques of study than to inculcate in him motives for and habits of vigorous, persistent effort. Developing a student into a good worker may perhaps be achieving the most important single educational objective. Whatever the techniques employed in study, the studious individual is a good worker. The habit of looking up words in a dictionary, frequently lauded, seems to be a fairly harmless habit, characteristic of the pupil who is less apt scholastically. —C.M.P.

CARROTHERS, GEORGE E. "The Proportion of Entering Pupils Graduated by Secondary Schools." *School and Society* 61: 12–14. January 6, 1945.

In 1944, there were living in the United States 3,684,263 graduates of colleges, approximately 3 per cent of our total population. Also, there were living 23,189,481 graduates of high schools, approximately 18 per cent of our total population. During the past several years, secondary schools

in this country have been enrolling up to 95 per cent of all teen-age youth.

In a study of enrollments in the high schools of Michigan during the period 1933–1943, the author found that the percentages of tenth and eleventh grade pupils remaining for graduation was greater in smaller high schools than in larger high schools. The percentage has been dropping since the beginning of the war, however. In 1941, 99 per cent of those beginning the senior year graduated, and in 1943 the percentage had dropped to 92 per cent. In the smaller high schools 68 per cent of all freshmen entering school in October, 1933, went on to graduation later; in 1942 the percentage was up to 81 per cent.

—C.M.P.

COLTON, F. BARROWS. "Our Global Ocean—and Last Frontier." *The National Geographic Magazine*, 87: 105–128. January, 1945.

Oceans cover nearly three-quarters of our earth. There is ten times as much water by volume in the ocean as there is land above sea level.

The ocean provides water for rain, greatly influences winds and weather, and distributes the sun's heat from the tropics toward the colder regions. Yet it is still largely a mystery, earth's last frontier, and the greatest field for future exploration.

In this global war we are extracting materials for weapons and supplies from the ocean depths. Bombers flying over the ocean are built partially of light-weight magnesium, extracted from sea water. Incendiary bombs also contain magnesium. Gasoline is given an anti-knock quality by a compound of bromine, another sea-water product. With a chemical outfit on life rafts a method has been found to make sea water drinkable by removing some of the salt.

Agar, the dried extract of a seaweed, is indispensable for such things as testing purity of water, milk, or food, and diagnosing nose and throat diseases.

Great areas of the undersea world still are entirely unexplored. Intriguing mysteries still hang over "old ocean's gray and melancholy waste." How do fish find their way through the limitless depths with no landmarks to guide them? Why do many salmon return from the sea to spawn in the streams where they were born, while eels do just the opposite, migrating 3,000 miles from European rivers to the warm Sargasso Sea to lay their eggs? What is the "chemical sense" by which blind fish find their food? Will more dry land areas gradually disappear under the sea, as did the Hudson Canyon and the regions now covered by the North Sea and English Channel?

—C.M.P.

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